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Petrology, geochemistry and economic geology of selected gold claims in rocks of the Wasekwan Lake area, Lynn Lake district, Manitoba, Canada

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Petrology, Geochemistry and Economic Geology of Selected Gold Claims in Rocks of the Wasekwan Lake Area, Lynn Lake District, Manitoba, Canada

by

Douglas Scott Kenaley

Bachelor of Science, University of Akron, 1979

A Thesis

Submitted to the Graduate Faculty

of the

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in partial fulfillment of the requirements

for the degree of

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This thesis submitted by Douglas Scott Kenaley in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

Frank R. Karner

Richard D. LeFever

Don L. Halvorson

This thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

A. William Johnson

Title Petrology, Geochemistry and Economic Geology of Selected Gold Claims in Rocks of the Wasekwan Lake Area, Lynn Lake District, Manitoba, Canada

Department Geology

Degree Master of Science

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Signature Douglas S. Kendig

Date 11/29/82

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VITA

Douglas Scott Kenaley was born July 5, 1957 in Akron, Ohio. Doug was graduated from East High School in Akron, on June 1975. He then completed the requirements for his Bachelor of Science Degree in geology, from the University of Akron, in 1979.

Mr. Kenaley is currently a student member of the Mineralogical Society of America and the American Institute of Mining, Metallurgical and Petroleum Engineers, a junior member of the American Association of Petroleum Geologists and a member of Sigma Gamma Epsilon, the National Honorary Society for the Earth Sciences.

Mr. Kenaley has had summer field experience as a Senior Field Assistant in 1980 with Washington Public Power and Supply System involved in uranium exploration in Quaternary to recent volcanic and sedimentary rocks and as a Senior Field Assistant in 1981 with Sherritt-Gordon Mines Ltd. involved in precious metal exploration in Precambrian volcanic and sedimentary rocks.

ABSTRACT

The purpose of this investigation was to map and study, both at regional and detailed scales, the units encountered within seven gold claims that were staked by Sherritt-Gordon Mines Limited of Lynn Lake, Manitoba. The claims are located in the Wasekwan Lake area, approximately 12.8 km southeast of Lynn Lake. Regional mapping was conducted at a scale of 1:12000 over a 6.4 km^2 area and detailed mapping of potentially economic areas was conducted at a scale of 1:240. Whole-rock geochemistry, microprobe, optical and X-ray diffraction procedures were employed to describe and characterize the rocks. The Aphebian rock units of the Wasekwan Lake area were divided into the following subunits:

Cockeram Lake aphyric andesite (2a), aphyric basalt (2b) and amygdaloidal basalt (2c); McVeigh Lake porphyritic andesite (3a), porphyritic basalt (3b), porphyritic breccia (3c); Fraser Lake aphyric andesite (4a), aphyric basalt (4b), amygdaloidal andesite (4c), amygdaloidal basalt (4d), porphyritic basalt (4e), mafic tuff (4f), highly altered mafic tuff (4fa), and intermediate tuff (4g); Pole Lake intermediate tuff (5a) and dacitic tuff (5b); Fraser Lake dacitic tuff (6d); Eldon

tuff (5b); Fraser Lake dacitic tuff (6d); Eldon Lake-Fraser Lake hornblende-bearing greywacke (9a), siltstone (9b) and garnet- and mica-bearing siltstone (9bg); subvolcanic intrusives (1); gabbro (13); tonalite (16a), quartz monzodiorite (16b), and granodiorite (16c); granodiorite (17); quartz plagioclase porphyry (22a), quartz diorite (22b); albitite (23a) and alkali-feldspar quartz syenite (23b).

These rocks exhibit upper greenschist to albite-epidote amphibolite facies metamorphism. Many of the units have been metasomatically altered, particularly the areas around the gold showings. The result of this alteration has been a combination of: feldspathization, tourmalinization, silicification, chloritization, sericitization, carbonatization, sideritization, pyritization, propylitization, hydration and beresitization.

Tectonically, these rocks are part of a double island arc system of volcanoes. Chemical data supports this conclusion. The volcanic rocks progress from an initial tholeiitic submarine basal sequence to a late-stage calc-alkaline cap which coincided with the emergence of the volcano from the sea. Five episodes of structural development have occurred resulting in very complex structural relationships. During structural development, a large shear system (the Cartwright Lake shear zone) formed and became a pathway for mobile elements which ultimately resulted in gold concentrations in favorable environments.

The gold occurrences are classified as gold-silver and silver-gold veins, lodes, stockworks, and silicified zones in a complex geological environment, comprising sediments, volcanics and various igneous intrusive and granitized rocks. The gold deposits are epigenetic and originated by derivation from the surrounding country rocks. Mobilization and subsequent transportation of gold in the form of various complexes was achieved by diffusion processes. Deposition occured in favorable environments such as first-degree dilatant zones (Central showing) and second-degree dilatant zones (Brown showing).

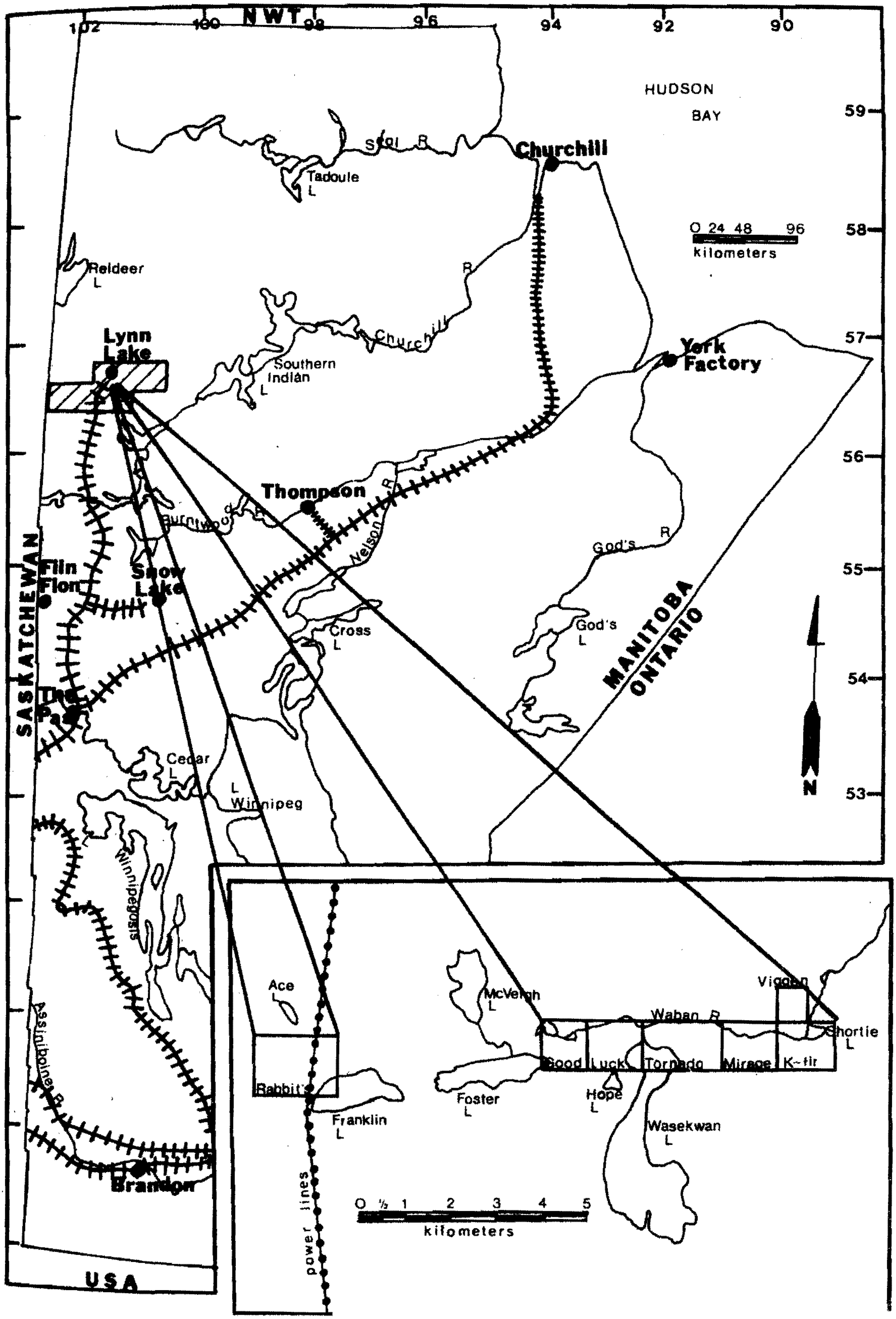
Chapter I

INTRODUCTION

1.1 LOCATION

The area included in this study is delimited by the boundaries within seven non-contiguous mineral claims staked by the Sherritt-Gordon Mines Limited exploration department during the winter of 1981. These claims are named from west to east: Rabbit's, Good, Luck, Tornado, Mirage, K-fir, and Viggen (Figure 1), and encompass an area of approximately 6.4 square km. They are located near Wasekwan Lake, approximately 12.8 km southeast of Lynn Lake, Manitoba, and approximately 800 km northwest of Winnipeg. The Lynn Lake district's boundaries are the interprovincial border of Saskatchewan on the west and Sickle and Barrington Lakes on the east. The northern and southern limits are defined by latitudes 57° 00' N and 56° 30' N.

Figure 1: Location map of the study area.


NWT
102
100
98
96
94
92
90
HUDSON
BAY
59
58
57
56
55
54
53
Seal R
Churchill
Tadoule L
0 24 48 96
kilometers
Reindeer L
Churchill R
Lynn Lake
Southern Indian L
York Factory
Thompson
Burntwood R
Nelson R
God's R
Flin Flon
Snow Lake
SASKATCHEWAN
Cross L
God's L
MANITOBA
ONTARIO
The Pas
Cedar L
L Winnipeg
Winnipegosis
N
Assiniboine R
Brandon
USA
Ace L
McVeigh L
Viggen
Waban R
Shortie L
Good
Luck
Tornado
Mirage
K-fir
Rabbit's
Foster L
Hope L
Franklin L
Wasekwan L
power lines
0 ½ 1 2 3 4 5
kilometers

1.2 PURPOSE AND APPROACH

Detailed petrographic descriptions, petrologic interpretations, and chemical descriptions of these rocks have not been attempted until recently and these interpretations have not been considered in the light of implications for gold ore genesis. Work of this type is required by Sherritt-Gordon Mines Limited to aid further evaluation on past, present and future prospects within the area.

The principal objectives of this investigation were:

1. To map the geology of seven claims near the Wasekwan Lake area at a larger regional scale than was previously done by Bateman (1945), Milligan (1960) and Gilbert et al. (1980).
2. To map the geology of the two gold occurrences within these claims at a larger local scale than Bateman (1945).
3. To describe in detail the petrology and geochemistry of the metavolcanic and metasedimentary rocks of the region, with particular emphasis on the determination of any conditions that would contribute to ore migration or deposition.
4. To help verify the regional petrologic interpretations of Gilbert et al. 1980.
5. To verify the interpretations of the local occurrences of Bateman (1945).

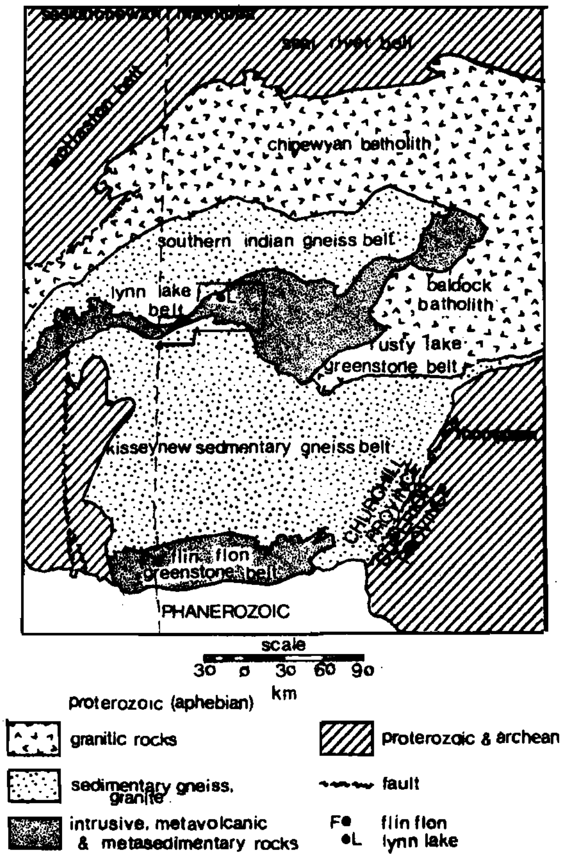
6. To interpret the geochemical characteristics of the igneous rocks and their origin, particularly in light of recent advances in plate tectonic theories.
7. To discuss possible models for the migration and deposition of gold ores.

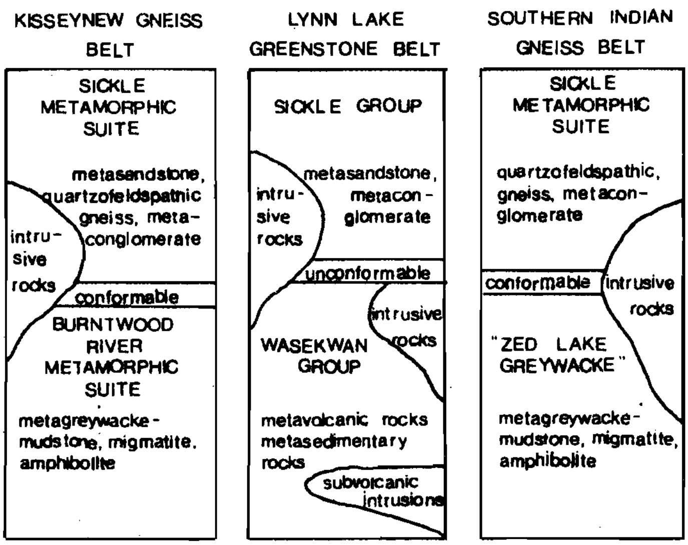
1.3 GEOLOGIC SETTING

Geologically, the Lynn Lake District is within the Churchill Structural Province. The boundaries for this province are marked by unconformities or by orogenic fronts. The oldest rocks of the province are Archean and are composed of basic to intermediate volcanic flows and pyroclastics, overlain by greywacke and shale. The various belts are isolated and trend north to northeast to easterly, are folded about northerly to northeasterly axes and metamorphosed to varying degrees. Aphebian rocks occur in a number of seperate belts in the Churchill Province and in places are known to rest unconformably on older Archean rocks. All Aphebian rocks have been folded and metamorphosed slightly to intensly by the Hudsonian orogeny. Three Aphebian lithostructural belts are found near the vicinity of the study area (Figure 2):

1. Part of the Southern Indian Gneiss Belt to the north which corresponds to the northwestern part of the Western La Ronge domain and the southeastern part of the Rottenstone domain

Figure 2: Structural setting of the Lynn Lake Greenstone Belt and stratigraphic outline for the Lynn Lake region (from Gilbert et al., 1980, p. 5-6).


wollaston belt
seal river belt
chipewyan batholith
southern indian gneiss belt
lynn lake belt
L
baldock batholith
rusty lake greenstone belt
kisseynew sedimentary gneiss belt
CHURCHILL PROVINCE
flin flon greenstone belt
PHANEROZOIC
scale
30 0 30 60 90
km
proterozoic (aphebian)
granitic rocks
sedimentary gneiss, granite
intrusive, metavolcanic & metasedimentary rocks
proterozoic & archean
fault
F flin flon
L lynn lake


KISSEYNEW GNEISS BELT
SICKLE METAMORPHIC SUITE
metasandstone, quartzofeldspathic gneiss, metaconglomerate
intrusive rocks
conformable
BURNTWOOD RIVER METAMORPHIC SUITE
metagreywacke-mudstone, migmatite, amphibolite
LYNN LAKE GREENSTONE BELT
SICKLE GROUP
metasandstone, metaconglomerate
intrusive rocks
unconformable
intrusive rocks
WASEKWAN GROUP
metavolcanic rocks metasedimentary rocks
subvolcanic intrusions
SOUTHERN INDIAN GNEISS BELT
SICKLE METAMORPHIC SUITE
quartzofeldspathic, gneiss, metaconglomerate
conformable
intrusive rocks
"ZED LAKE GREYWACKE"
metagreywacke-mudstone, migmatite, amphibolite

2. A large portion of the Lynn Lake Greenstone Belt through the center (Gilbert et al., 1980); and
3. A part of the Kisseynew Sedimentary Gneiss Belt to the South (Gilbert et al., 1980).

Gilbert et al. (1980) have extensively studied the volcanic rocks of the district (Wasekwan Group). In this work, the Wasekwan group was divided into a relatively younger "northern belt" and a relatively older "southern belt". The northern belt consists of mafic metavolcanic rocks with minor associated felsic and intermediate units. Compositionally, these rocks are tholeiitic basalts and andesites with some occurrences of high alumina basalt and andesite (Al_2O_3 greater than 18%). The southern belt, which includes the area of this study, is composed of a large interval of porphyritic and aphyric tholeiitic basalts. Discontinuous units of metasedimentary rocks or, in some areas, a heterogeneous assemblage of mafic, intermediate and felsic metavolcanic rocks overlie the basalts. Iron formation occurs in some areas. Chemically, the overlying rocks are predominantly tholeiitic with a calc-alkaline volcanic and sedimentary capping succession. The Zed Lake Greywackes to the north and the Burntwood River Metamorphic Suite to the south are interpreted as coeval with the Wasekwan Group.

The Sickle Group (Norman, 1933), composed of conglomerates and sandstones, rests unconformably on the Wasekwan Group and on felsic and mafic plutonic rocks in the southern and central portions of the Lynn Lake Greenstone Belt. The Sickle Metamorphic Suites to the north and south of the Lynn Lake Greenstone belt are thought to be equivalent to the Sickle Group but differ by conformably overlying the suites below.

Deformation and plutonism has occurred during and after the deposition of the Wasekwan Group and again after the deposition of the Sickle Group. The resulting complex structural history of the area is summarized in figure 3. Metamorphism progresses from the middle greenschist facies in the east to the lower amphibolite facies in the west.

Ages within the Lynn Lake Greenstone Belt were determined with Rb-Sr methods by Clark (1980). The Wasekwan metavolcanic rocks were determined to be 1835 $\pm$ 75 Ma, which is consistent with a late Aphebian age for volcanism. The Sickle Group was found to be 1760 $\pm$ 85 Ma to 1940 $\pm$ 75 Ma.

Figure 3: Structural evolution of the Lynn Lak region showing the order of emplacement of the Wasekwa and Sickle Groups with respect to the structural an intrusive events of the area (from Gilbert et al. 1980 p. 10).

	faulting, northerly, e.g. Muskeg Lake; northwest, e.g. Lynn Lake
D5	continued development of foliation, cataclasis (northeasterly); open cross folding felsic intrusion, e.g. Burge Lake Rb-Sr w.r. age: 1765±100 Ma metamorphism locally retrograde
D4	shearing, faulting (east and northeasterly, e.g. Cartwright Lake) formation of basins and domes (north and east trending) e.g. Hughes Lake development of foliation, regional metamorphism anatexis, Rb-Sr w.r. age 1.74-1.78±0.1 Ga mafic to felsic intrusion, e.g. Laurie Lake
D3	thrusting at the belt margins, e.g. Tod Lake
	diorite intrusion (Black Trout) SICKLE GROUP (shallow water, terrestrial)
D2	uplift, erosion, faulting, tilting
	felsic intrusion, e.g. Hughes Lake Rb-Sr w.r. age: 1940±75, 1825±210 Ma
	mafic intrusion, e.g. Lynn Lake
D1	folding, faulting (east-northeasterly)
	WASEKWAN GROUP mafic to felsic intrusion mafic to felsic tholeiitic and calc-alkaline volcanism
	felsic volcanism, faulting, sedimentation
	mafic tholeiitic volcanism

1.4 PREVIOUS WORK

Prior to 1930, little exploration had taken place in the area. A few track surveys had been made in adjacent areas (Tyrrell and Dowling, 1880; Bell, 1880; McInnes, 1913; Alcock, 1920; Stockwell, 1928); these were restricted by accessibility.

Mapping within the district began after 1930 with the work of Norman (1933). The Sickle Group was described in this work as well as a "pre-Sickle group" of greenstones unconformably underlying it. Most of the intrusives were reported to be post-Sickle. Two reconnaissance maps at a scale of four miles to the inch were published. Maps of the Brochet area to the north, and the Uhlman Lake area to the east were later published at the same scale (Gadd, 1950 and Wright, 1953, respectively). Subsequently, the McVeigh Lake area was mapped at a scale of 1:1500 by Bateman (1945); the Wasekwan Series was named and divided into eight divisions of volcanic and sedimentary rocks, typically represented by outcrops in the vicinity of Wasekwan Lake. This series was confirmed to be unconformably overlain by the sedimentary Sickle Series. Bateman found that the intrusive rocks are both pre- and post-Sickle in age.

Extensive exploration activity within the area resulted in a very complete regional synthesis by Milligan (1960). This report was based on fourteen 15-minute map sheets and stressed the identification of distinct lithologic units.

The resulting units contain eight lithologic divisions of metavolcanic and metasedimentary rocks belonging to the Wasekwan Series, four pre-Sickle, predominantly felsic intrusive types, two Sickle Series divisions composed of metamorphosed arkoses, sandstones and conglomerates, and five divisions of post-Sickle felsic intrusives. Granitic rocks of uncertain age were also noted.

In 1961, Emslie and Moore produced a report of geological studies in the area between Lynn Lake and Fraser Lake. Nine Wasekwan Series lithologic members were recognized and each contained many submembers. A map at the scale of 1:2,000 was published with this report. Davies et al. (1962) provided an updated review of the economic geology of the area. In 1972, Campbell compiled a stratigraphic and structural study of the Granville Lake-Lynn Lake region, with particular emphasis on the lithology and depositional regimes of the Sickle Series. This report was complemented by a study of the Lynn Lake volcanic rocks by Zwanzig (1974). In this report, the volcanic rocks were divided into distinct northern and southern belts.

Factors contributing to renewed interest in this area are the publication of the Questor airborne geophysical maps of the Fox Lake, Lynn Lake and Barrington Lake areas in 1976 and 1977 (Airborne Electromagnetic Survey, 1977) and the decrease in production and closing of many of the mines.

A thorough study by Gilbert et al. (1980) has resulted in a detailed definition and description of the Wasekwan volcanic rocks. Five preliminary maps at a scale of 1:50,000 were produced, as well as a subsequent revised (1980) compilation map at a scale of 1:100,000. Lithologic units and the evolution of local volcanic and sedimentary units were discussed. Mineral potential studies (Gale et al., 1980; Pinset, 1980) were initiated at this time. An updated geochronology study (Clark, 1980) was also completed and verified an Aphebian age for the Wasekwan Series. The general tectonic evolution of the area was considered by Lewry (1981) and Zwanzig et al. (in prep.).

Economic interest in the area has varied over the years. Early attention was directed toward gold. Diamond drilling was reported by Stockwell (1928) at Reindeer Lake but little activity was generated. The Caribou showing on Barrington Lake was staked in 1930. In 1934, prospects at Paskwachi Bay on Reindeer Lake and a showing at Cartwright Lake were staked. Many claims were staked at Beaucage and Black Trout Lakes, resulting in a gold discovery in 1937 near Lasthope Lake. One of the largest blocks of surveyed claims held by a mining company anywhere in Canada was consolidated between 1938 and 1940 by Sherritt-Gordon Mines Limited, between Fraser Lake and Moses Lake, and extending south to Lasthope Lake. Most of these claims were eventually allowed to lapse, but in the winter of 1981 some were restaked; a portion of these included the area of this study. During 1939, 140,000 tons of gold ore were confirmed by diamond drilling at Lasthope Lake. In 1941, massive pyrrhotite was located at what was later named the "A" orebody of the Sherritt-Gordon Farley Mine at Lynn Lake. Confirmation of a large Cu/Zn ore body occurred in 1945 and was followed by a staking rush. The nearby EL orebody was located and verified by 1950. This brought the established ore reserves up to 14 million tons of Cu/Zn, which allowed the development of the mines to proceed. The "Z" deposit was discovered in 1946 (153,000 tons Cu/Zn) and the Goodenough body in 1947 (182,000 tons Cu/Zn). The Agassiz property (1.5 million tons Au), staked in 1946, was acquired by the Central Manitoba Mines and later by Sherritt-Gordon Mines Limited. The Barrington Lake property and D.H. and F.L. properties (250,000 tons and 500,000 tons Cu ore respectively) were also staked in 1946.

Few substantial new mineral finds have been located since 1950. Silver was discovered in 1955 (George Group) and a few more copper occurrences were found and staked in 1961. The most important of these was the FOX group which became the Fox Mine in 1970 (estimated reserves in 1977 were 7,093,000 tons 1.83% Cu and 2.12% Zn-Gilbert et al, 1980). The most recent orebody discovery was in 1969 (the Ruttan Lake Cu/Zn orebody).

Since 1969, only minor Cu/Zn and Au occurrences have been reported by Sherritt Gordon.

Chapter II

METHODS AND PROCEDURES

2.1 MAPPING

Geologic mapping of the Wasekwan Lake area claims was accomplished from May through August of 1981. Pace and compass procedures were followed, using enlarged air photos (1:12,000) as a means of control and as base maps. Local mapping at a scale of 1:240 was effected by the means of staking by Brunton compass surveying methods, using a 20-foot grid over the area to be mapped. A tape was then utilized to measure the location of the trenches and contacts from each stake. Graph paper with the stake locations superimposed was used as a base.

Information compiled on the final geologic maps includes lithologic unit divisions according to Gilbert et al. (1980) and Bateman (1945), subunit divisions by the author, contacts, attitudes of rock and structural features, sample locations, and igneous outcrops, as well as nearby map control features such as claim lines, power lines, lakes, streams, sand hills and muskeg occurrences.

2.2 SAMPLING PROCEDURE

Mapping of the Wasekwan Lake area included sampling and field description of rock types. Initial field nomenclature followed Travis (1955) and was based primarily on the characterization of metamorphic minerals and fabrics. For igneous rocks, the classification of Streckeisen (1973) was used.

A suite of 209 rocks of various associations were collected for subsequent petrologic examination, with sampling dependent on outcrop availability and lithologic variability. For each suite sample taken and for other minor occurrences, a fresh one-kilogram sample was obtained at the outcrop for use in later whole rock geochemical analysis. If mineralization indicated the possible presence of precious metals, samples were collected for immediate assay analysis by Sherritt-Gordon Mines Limited. Units that had lithologic similarities over large areas were described and differentiated in the field.

Geochemical sampling locations were numbered serially and are plotted on plates I-III. Specimens obtained for thin section analysis were also numbered serially and had one of the prefixes "JS" (denoting regional Johnson Shear origin), "JSB" (denoting local Johnson Shear Brown showing) or "JSC" (denoting local Johnson Shear Central showing). For example, JS-10 is the sample collected from site 10 of the regional mapping survey and JSB-3 is the sample collected from site 3 of the local Brown showing. Areas that were described but had no samples collected were denoted by a "JS" prefix and followed by the date and serial number of the site. For instance, JS 7-5-4 is the sample described at the fourth site on July 5 but no sample was taken. A few of these also appear on plate I. The name Johnson Shear was initially chosen for the sample numbers because the Sherritt-Gordon exploration staff refers to the area around Wasekwan Lake by this name.

2.3 MODAL ANALYSIS

Polished petrographic thin sections were used for modal analysis of the rocks of the Wasekwan Lake area. This analysis consisted of 500 points counted per thin section, with the grid spacing chosen according to convention as one-half the average grain size of the largest constituent. The accuracy of a given mode is given by Van der Plas and Tobi (1965) as a relative percentage of each phase: the percentage of 28-80% varies ± 4%, 13-28% varies ± 3%, 5-13% varies ± 2% and 1-5% varies ± 1%. In cases where fine-grained, untwinned, anhedral, plagioclase and anhedral quartz occur together, the inaccuracy of the point count, and thus the variability, is much higher. In such a case, the lowest of the two modes should be taken as a minimum and the highest as a maximum. For example, if there is a reported 15%, fine-grained, untwinned, anhedral, plagioclase population and 25% fine-grained quartz, then these values should be taken to mean that there is at least 15% plagioclase and no more than 25% quartz within the thin section. The identification of major mineral phases within rock units was verified by X-ray diffraction. Both major and minor mineral compositions were verified by electron microprobe techniques.

2.4 X-RAY DIFFRACTION

The methods used in the preparation of samples for X-ray analysis were those used by the Natural Materials Analytical Laboratory (NMAL) at the University of North Dakota Geology Department. The following procedure was used:

1. The sample was crushed in a mortar until a fragment size of less than 1 centimeter was achieved.
2. Half of this sample was crushed to less than three millimeters in size.
3. Twenty grams of this sample were ground to less than 20 mesh (0.84 mm) in the Spex Mixer Mill (vial number 8004) for approximately five minutes.
4. Two grams of this sample were ground to less than -325 mesh (44 microns) in the Spex Mixer Mill (vial number 5004).

One gram of the resultant sample (44 microns) was backloaded into an aluminum holder after it was mixed with silicon powder.

A Philips-Norelco high-angle diffractometer was used in the analysis with Cu K-alpha radiation generated at 37 Kv and 18 mA. For verification of major phases, samples were scanned from 2° to 56° $2\ \theta$ at 1° $2\ \theta$ per minute.

2.5 ELECTRON MICROPROBE ANALYSIS

Samples used for the analysis of mineral composition by electron microprobe techniques were polished petrographic thin sections. The samples were carbon coated using a Denton Vacuum DSM-5E cold sputter etch module. A JEOL 35C scanning electron microscope was used in conjunction with a Kevex energy dispersive detector. The resulting X-ray spectrum obtained was processed by a Tracor Northern XML fitting program and the matrix correction program of Bence and Albee (1968). All microprobe chemical analyses presented were determined by electron beam techniques developed for polished thin sections using inter-laboratory standard curves. Analyses are expressed in oxide weight percentages with total iron reported as Fe_2O_3. The number of ions present is given on the basis of a specific number of (O,OH) as determined by the chemical analyses of Deer, Howie and Zussman (1962a-c and 1963a and b). Analyses were compared with those of Deer, Howie and Zussman and a "best fit" was determined for the identification of a specific mineral species. In some cases, special ratios, which were used to aid determination of the mineral species, are listed. One such ratio applied to amphiboles is calculated as $100Mg/(Mg+Fe_T+Mn)$ and is abbreviated within the applicable tables as AR (amphibole ratio).

2.6 CHEMICAL ANALYSIS

Whole rock chemical analyses for the samples collected were done by X-ray Assay Laboratories Limited of Don Mills, Ontario. Table 1 summarizes the techniques used in the determination of elements within the rocks. A brief description of each procedure is given below (Opdebeeck, 1982, personal communication).

2.6.1 Sample Preparation

The rocks were crushed first in a jaw crusher and then by a cone crusher to reduce samples to 1/4 inch or less. A 100-gram split is ground in a chrome steel mill to -200 mesh (75 microns).

2.6.2 X-ray Fluorescence Spectrometry (XRF)

A 1.3-gram sample, after roasting at $950^{o}C$ for one hour, was fused with five grams of lithium tetraborate and the melt was cast into a 40-millimeter button. The button was analyzed on a Phillips DW1600 simultaneous X-ray fluorescence spectrometer which is calibrated with more than 40 reference materials. Most calibration materials are tabulated in Abbey's (1977) "preferred" values compilation.

TABLE 1

Elements Analyzed, Units, Methods of Analysis and the Detection Limit of Each Method, for Geochemical Samples in this Study.

Element	Units	Method	Detection Limit
SiO_2	wt. %	XRF	0.01
Al_2O_3	wt. %	XRF	0.01
Fe_2O_3	wt. %	XRF	0.01
FeO	wt. %	WET	0.1
CaO	wt. %	XRF	0.01
MgO	wt. %	XRF	0.01
Na_2O	wt. %	XRF	0.01
K_2O	wt. %	XRF	0.01
H_2O+	wt. %	WET	0.1
H_2O-	wt. %	WET	0.1
TiO_2	wt. %	XRF	0.01
P_2O_5	wt. %	XRF	0.01
MnO	wt. %	XRF	0.01
CO_2	wt. %	WET	0.1
SO_3	wt. %	XRF	0.002
Cu	ppm	DCP	0.5
Ag	ppm	DCP	0.5
Au	ppb	FADCP	2.0
Zn	ppm	DCP	0.5
Y	ppm	XRF	10.0
Pb	ppm	DCP	2.0
Zr	ppm	XRF	10.0
As	ppm	NA	1.0
Sb	ppm	NA	0.2
V	ppm	DCP	2.0
Cr	ppm	XRF	10.0
Mo	ppm	DCP	0.5
Co	ppm	DCP	0.5
Ni	ppm	DCP	0.5

wt. % -----weight percent
ppm---------parts per million
ppb---------parts per billion
XRF---------X-ray fluorescence
WET---------wet chemical
NA----------neutron activation
DCP---------direct current plasma emission
FADCP------fire assay and direct current plasma emission

Counting time on major elements was 60 seconds with each element analyzed for through its own fixed channel.

Trace elements in this package are run as counts and are accumulated for the majors using a scanner. All elements determined are added and any samples with a sum of less than 98% or higher than 101% are automatically repeated. Instrument precision on most elements is better than .5%. Only at low detectability would an error of 1-2% occur.

2.6.3 Determination of Ferrous Iron by Oxidation (WET)

This method is based on the quantitative oxidation of ferrous salts in acid solutions to the ferric oxidation state using potassium dichromate. One-half gram of sample is weighed and digested with a mixture of sulfuric, hydrochloric and hydrofluoric acids. A sulfuric-phosphoric acid mixture is added and the solution is cooled. After adding a few drops of the redox indicator sodium dephenylamino-sulfonate, the solution is titrated with a standarized potassium dichromate solution.

2.6.4 Combined Water (WET)

The sample is dried for three hours at 110^{o}C to drive off any moisture present. The sample is then mixed with PbO and heated in a Pyrex test tube. Any water vapor will be condensed on a piece of preweighed paper in the upper part of the test tube. This part of the test tube is cooled by ice in a polyethylene jacket. The weight gained on the paper is the amount of H_2O^+ in the sample. The typical sample size is one gram.

2.6.5 Titrimetric Determination of CO_2 (WET)

A half-gram to one gram sample is weighed and digested with hydrochloric acid. This liberates carbon dioxide which is dissolved in a known volume of saturated barium hydroxide solution and forms $BaCO_3$. The excess $Ba(HO)_2$ is titrated with diluted HCl using phenolpthalein as indicator. Blanks and rock standards are run with each batch of samples to monitor the complete process. For CO_2 values of more than 10%, a smaller sample is used.

2.6.6 Co, Ni, Cu, Zn, Mo, Ag, Pb by Direct-Current Plasma Emission Spectrometry (DCP)

A quarter-gram sample is digested with 2 ml of nitric acid for a half hour in a water bath, then 1 ml of hydrochloric acid is added and the digestion continues for another two and one-half hours. Samples are then made up to standard volume with lithium buffer and run on the simultaneous direct current plasma emission spectrometer. In-house standards and previously analyzed samples are run to monitor proper digestion procedures. Synthetic standards are used to calibrate the instrument.

2.6.7 V Determination by Direct-Current Plasma Emission Spectrometer (DCP)

A 0.05-gram sample is fused with three pellets of KOH in a nickel crucible, and the cake is dissolved in 5% HCl. The resulting solution is run on a Spectrometrics direct current plasma emission spectrometer using the echelle grating. A detection limit of 2 ppm is easily attained. In-house standards, previously analyzed samples and international reference materials are used to calibrate and monitor the fusion procedure.

2.6.8 Au Analysis by Fire Assay-Direct Current Argon Plasma Emission Spectrometry (FADCP)

2.6.8.1 Machine Calibration

The Spectrometrics Model III Echelle Spectrometer with direct current argon plasma excitation is calibrated using synthetic gold standards prepared by dilutions of a stock solution with the addition of sufficent aqua regia to match the sample matrix. A high standard of 10 ppm is used with a distilled water blank as low standard. The freshly prepared standards are checked against a known reference solution and intermediate standards of 1 ppm and 5 ppm are also run. High and low standards are checked after every 12 samples and mantained to $\pm$ 2%.

2.6.8.2 Sample Preparation

Silver beads containing the precious metals are obtained by fire assay collection procedures and digested in the following manner. The beads are flattened to facilitate acid attack and loaded in test tubes. One-half ml of 1:1 nitric acid is added to dissolve silver. Samples are placed in a hot water bath (60^{o}C) for 30 minutes or until the dissolution of the silver bead is complete. One ml of aqua regia is added and heating continued until all of the gold is dissolved. Samples are cooled and diluted to a total volume of 5 ml with distilled water.

2.6.8.3 Data Collection

Each solution is run twice on an integration of eight seconds and the two values obtained averaged to give the final result. Any samples for which the gold concentration is outside the calibration range are diluted 1:10 by means of an automatic dilutor.

2.6.8.4 As and Sb Analysis by Neutron Activation (NA)

A half-gram sample is weighed into a small polyethylene vial which after sealing is irradiated in an epithermal flux of approximately 10^{12} neutrons per cm^2/sec for 50 minutes. After a four day waiting period, the intensity of the ^{76}As and ^{122}Sb gamma emissions are measured at 559 and 564 KeV. Calibration is based on standards prepared from high-purity arsenic and antimony. The analytical instrument is a multichannel analyzer connected to a pacified hyperpure germanium detector.

2.7 DATA RELIABILITY

Due to the emphasis placed on the geochemical data in this study, its reliability was monitored in two ways.

Approximately one of every ten samples collected in the field was split into two separate samples. A direct comparison of the two analyses was then made. Very little deviation was noted and in no case did the computer program that determined a rock name from the normative chemistry derive a separate name for any of these split samples.

The second monitoring process used involved a "standard" Lynn Lake basalt which was obtained from the field. The rock had been crushed to fragments less than one centimeter in diameter to provide a more homogeneous sample. Approximately every fifteenth sample submitted was this basalt (named "check basalt" in the appendices). The resulting analyses were tabulated and log/log plots were constructed, plotting the coefficient of variance (C.V.%) versus weight percent or concentration in ppm (figures 4 and 5). The resulting points were then compared with lines that represented various weight percentage variance limits. For example, a sample that had a concentration of 200 ppm and a C.V. of 5% would be accurate to within $\pm$ 10 ppm. For the same sample to vary within the $\pm$ 10 ppm range but only have a true concentration of 2 ppm, a C.V. of up to 500% could be tolerated. Lines were constructed to show ± 0.01 wt.%, ± 0.1 wt.%, ± 1 wt.%, ± 1 ppm, ± 10 ppm, ± 20 ppm, ± 30 ppm and ± 40 ppm. The resulting plot indicates the degree of accuracy that the analysis can be reguarded.

Of the major oxides, all but one was shown to vary below ± 1 wt.%; in fact, more than half showed less than a ± 0.1 wt.% variability. The only analysis which showed unacceptable limits was loss on ignition (LOI); therefore, this analysis was never employed in the determination of rock characteristics.

The minor oxides all were shown to vary by less than ± 40 ppm. The great majority fall below a ± 10 ppm variance and almost half fall below the ± 1 ppm limits.

Figure 4: Major oxide replicate analysis plot
the coefficent of variance (C.V.) versus weight per
(wt. %) on a log-log scale.

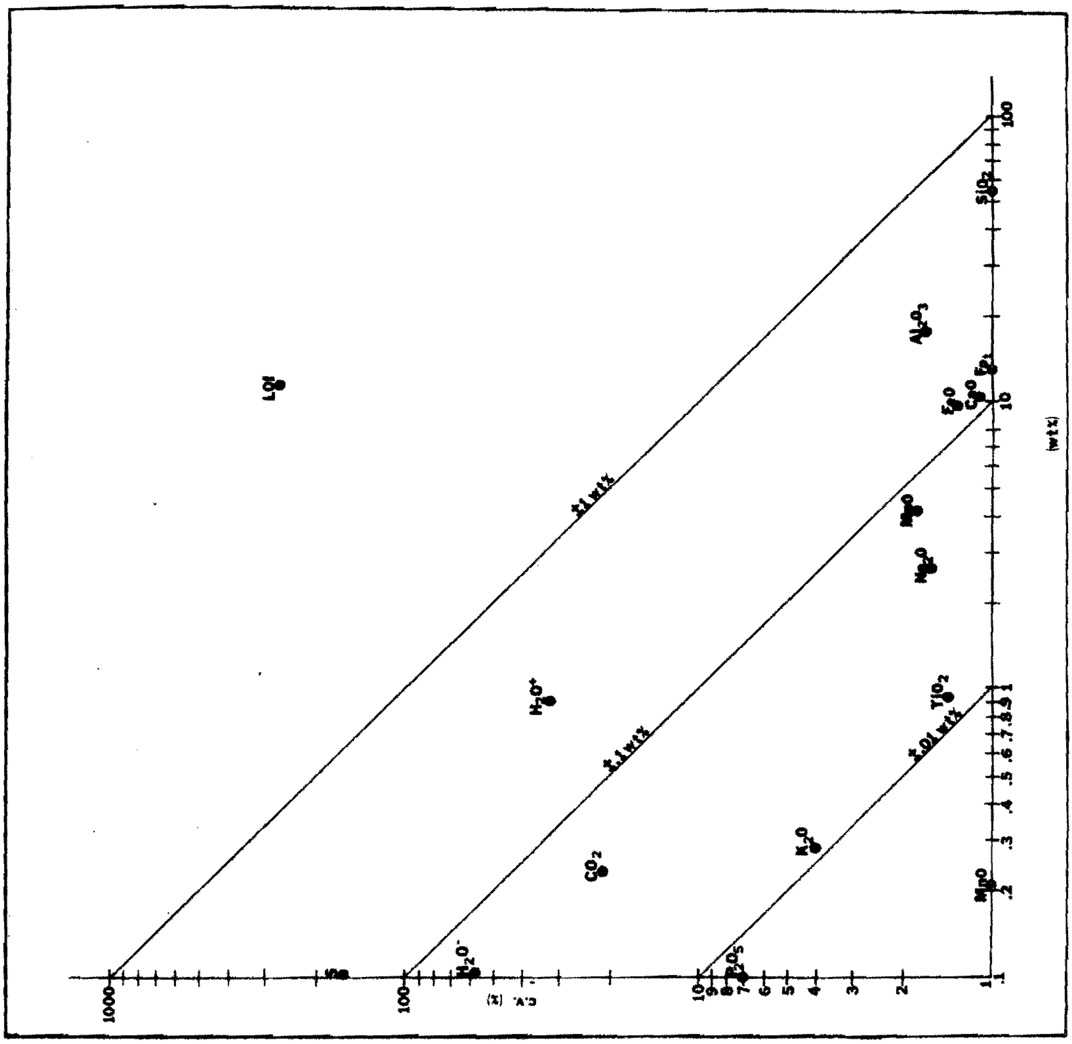
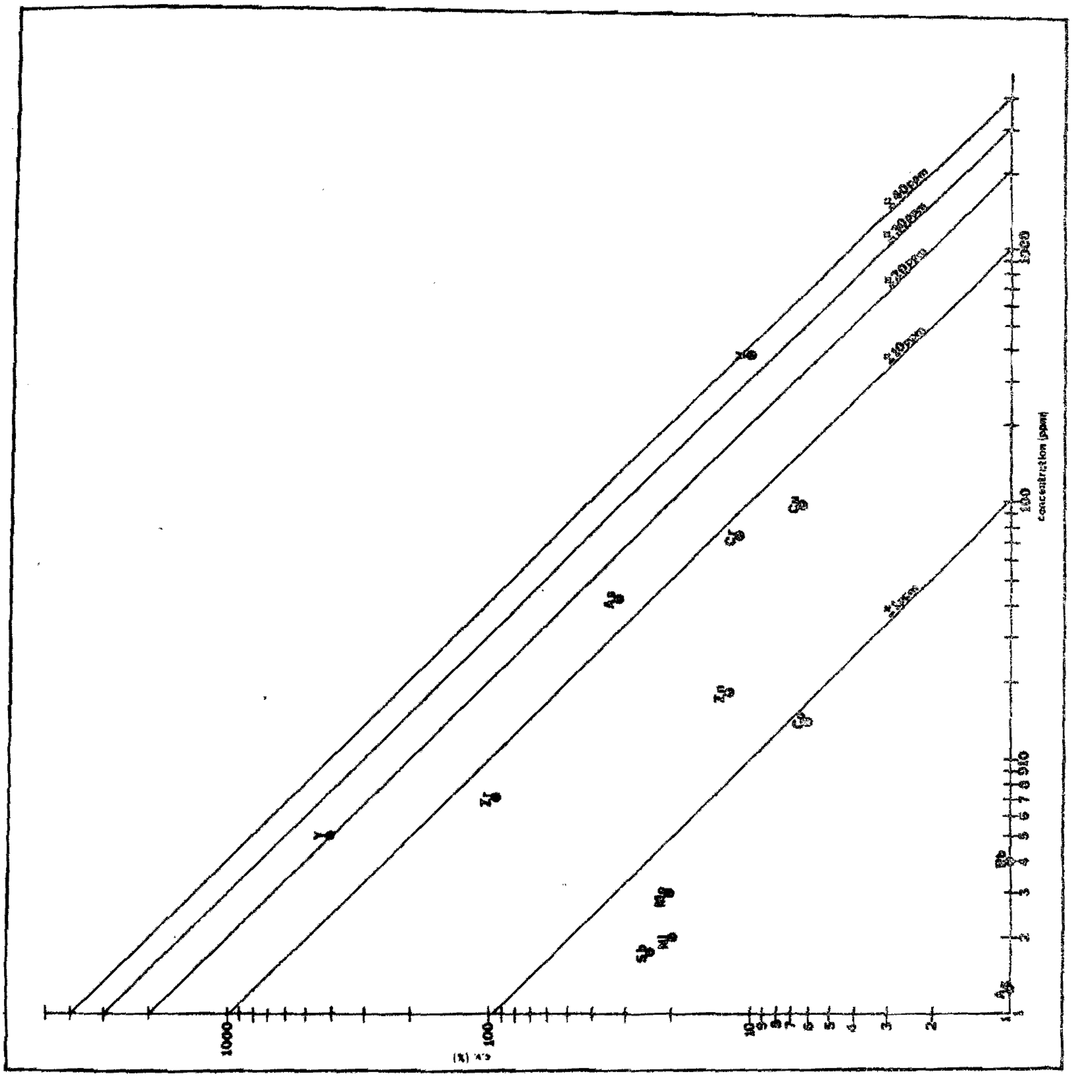

±1 wt%
±.1 wt%
±.01 wt%
(wt%)
C.V. (%)
LOI
SiO2
Al2O3
CO2
K2O
TiO2
P2O5

Figure 5: Trace element replicate analysis plotting the coefficent of variance (C.V.) versus concentration in parts per million (ppm) on a log-log scale.


±40ppm
±30ppm
±20ppm
±10ppm
±5ppm
concentration (ppm)
c.v. (%)

2.8 COMPUTER EVALUATION OF CHEMICAL DATA

A computer program based on Bingler et al. (1976) was utilized. The major oxides, SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, TiO_2, P_2O_5 and MnO, were normalized to readjust for the volatiles H_2O and CO_2 and to help minimize the effects of alteration. Fe_2O_3, which can appreciably affect the norm, was adjusted after the method of Irvine and Barager (1971) to achieve a more close primary rock composition.

The program was modified by R. D. LeFever to incorporate normative minerals into a standardized rock name after Streckeisen (1973). Since this classification was too precise for these metamorphic rocks, all types of basaltic rocks (e.g. quartz latite basalt) are here called "basalt" and all andesitic rocks (e.g. quartz latite andesite) are called "andesite". Care should be exercised when comparing these names to others in the literature. There does seem to be an extremely good correspondence of rock names when comparing the program names with those based solely on SiO_2 as given by Gilbert et al. (1980). The primary advantage of the normative Streckeisen scheme is that it is not based on only one highly mobile element (e.g. SiO_2).

The rocks were plotted according to convention on AFM and YTC diagrams to characterize their tholeiitic and calc-alkaline affinities. The chemical trends for the fields can be found in Irvine and Barager (1971) for the AFM diagram and Davies et al. (1979) for the YTC diagram. A comparison of the two diagrams gives a quantitative indication of the degree of metasomatic alteration because Y + Zr, Ti and Cr are relatively immobile under metamorphic conditions when compared to $Na_2O + K_2O$, Fe_2O_3 and MgO.

All intrusive rocks were characterized modally and these modal analyses were directly applied to the Streckeisen (1973) classification scheme. In this case, any presence of metasomatic minerals (e.g. quartz or An_2 albite) can significantly alter the name.

Volcanic terminology is after Trowell et al. (1978). Metasedimentary rock nomenclature was used according to Gilbert, et. al. (1980). The classification is very general in that only "greywacke" and "siltstone" names are derived. All rocks are metamorphosed to at least the greenschist metamorphic facies; therefore, a "meta-" prefix is assumed. Sedimentary rocks containing greater than 10% secondary hornblende are considered to be greywackes and those with less than 10% are called siltstones. Due to the destruction of all or most of the primary mineralogy, no attempt was made to distinguish further subdivisions such as feldspathic greywacke. These sedimentary units were subdivided according to metamorphic assemblages (e.g. hornblende-bearing greywacke or garnet mica siltstone).

Cases in which rocks appear to be very highly altered are noted and are separated into their own units.

Normalized chemistry, normative mineralogy and normative color index are listed within the text. Appendix A contains all of the chemical analyses and Appendix B all of the derived norms from these analyses.

Chapter III

REGIONAL PETROLOGY AND GEOCHEMISTRY

3.1 VOLCANIC ROCKS

3.1.1 Cockeram Lake Aphyric Basalt and Andesite (unit 2)

3.1.1.1 Occurrence

The Cockeram Lake unit represents the second largest volume of extrusives within the map area. The unit occupies the northern portion of most claims in the study area.

In the eastern five claims, the contact to the north is with an intrusive gabbro (unit 13). In the Rabbit's claim, unit 2 is in contact with McVeigh Lake volcanic rocks (unit 3). The unit's southern contact is with the Fraser Lake-Eldon Lake sedimentary section (unit 9) in all six claims. An apposition of Fraser Lake volcanic rocks (unit 4) with the Cockeram Lake unit occurs in the central and western Rabbit's claim so that unit 2 also has a southern contact with unit 4 (Plate I).

A major fold, the McVeigh Lake anticline, extends along the strike of this unit and probably produces structural repetition and thickening (Gilbert et al. 1980). They also report that this aphyric basalt is the same age as the porphyritic and aphyric basalt (unit 3) at McVeigh Lake. This relationship is evident where portions of the aphyric pile (unit 2) are found to both underlie and overlie part of the porphyritic sequence (unit 3).

3.1.1.2 Field Observations

The Cockeram Lake basalts and andesites are dark grey on weathered surfaces and medium to dark green-grey on fresh surfaces. They are usually fine-grained with visible amphibole and plagioclase. Outcrops appear rather blocky with prominent jointing. Quartz stringers up to 2.5 cm across occur commonly and there is usually moderate to intense silicification along jointing surfaces. Minor calcite and sulfides are also present. A few percent of the unit is composed of tuffaceous and sedimentary sequences. No pillows are noted, although Gilbert et al. (1980) report pillows farther to the east. Amygdaloidal members occur throughout, and in some places flow tops can be distinguished by their highly amygdaloidal nature.

Unit 2 has been divided into three members: an aphyric basalt (subunit 2a), an aphyric andesite (subunit 2b) and an amygdaloidal basalt (subunit 2c).

3.1.1.3 Mineralogy and Chemistry

The typical unit 2 mineralogy (Table 2) contains a high percentage of fine-grained (to .44mm) with minor medium-grained (to 1.1mm), anhedral to subhedral, fibrous, blue-green pleochroic amphibole (Figure 6). Poikiloblastic opaques and plagioclase occur in small amounts and minor chlorite alteration has occurred around the edges. A "felted" texture is exhibited by these amphiboles and some linearity is thus imparted to the predominantly hornfelsic nature of the rock. The amphibole composition (Table 3) is determined to be within the tschermakitic hornblende range. Unit 2 also contains major amounts of fine-grained (to .8mm) plagioclase. The most common forms are anhedral, rarely albite-twinned, epidotized and sericitized, normally-zoned, fine-grained "clots" and as an anhedral, untwinned, annealed mosaic groundmass. Rare examples of coarse-grained plagioclase phenocrysts (up to 4.25mm) which are anhedral, albite-twinned and exhibit overgrowth rims do occur. Epidote and amphibole poikiloblasts are found within these grains. Medium- to coarse-grained plagioclase amygdaloidal fillings can also be found. The anorthite content of the plagioclase as determined by the Michel-Levy method is An_{34}. Microprobe analysis (Table 3) also yields an An_{34} anorthite content.

The most noteworthy minerals of unit 2 and other volcanic rocks in the area are the opaques. Unit 2 contains an average of 2% opaques, most of which exhibit a "relict" appearance in that they seem to resemble the remains of an original crystal, perhaps olivine or pyroxene. This "relict" morphology is exhibited in two ways. The most common is concentrated areas of fine-grained opaques (Figure 7).

TABLE 2

Point Counted Modes and Average, Visually Estimated Modes of Cockeram Lake Aphyric Basalt and Andesite (unit 2)

UNIT	2a	2a	2a	2b	2b	2b	2c	2c	2c
SAMPLE	066	085	$\bar{X}$ N=7	014	080	$\bar{X}$ N=3	037	144	$\bar{X}$ N=3
Quartz	.6	1.6	5.2	5.2	-.-	3.4	1.4	2.2	1.5
Plagioclase	43.2	35.2	32.2	40.6	29.4	28.3	45.0	22.6	38.2
White Mica	pr.	pr.	pr.	.4	pr.	.2	8.2	pr.	2.8
Chlorite	-.-	.2	1.2	15.4	-.-	5.2	pr.	pr.	.1
Amphibole	51.8	61.4	55.3	36.4	67.8	59.7	40.8	72.0	54.3
Epidote	.2	.2	.3	pr.	pr.	.7	4.6	pr.	1.9
Carbonate	-.-	-.-	.5	1.2	pr.	.4	pr.	pr.	.4
Opaque	4.2	1.4	3.2	.8	2.8	2.5	pr.	3.2	1.4
Amygdales	-.-	-.-	-.-	-.-	-.-	-.-	23.0	18.0	19.0

X- mean
pr.- present

Figure 6: Photomicrograph of amphibol (tschermakitic hornblende) groundmass of Cockera aphyric basalt sample 121. White areas are an plagioclase grains. Plane polarized light, 372x.

TABLE 3

Typical Chemical Composition of Subunit 2b Minerals

SAMPLE	AMPHIBOLE	PLAGIOCLASE	OPAQUE
SiO2	39.8	56.4	6.4
Al2O3	13.2	23.2	-.-
FeO	20.5	0.3	45.3
MgO	5.6	0.1	0.2
CaO	11.1	6.2	0.1
Na2O	1.5	6.6	-.-
K2O	0.4	-.-	-.-
TiO2	.01	-.-	49.9
P2O5	0.0	-.-	-.-
MnO	0.0	-.-	1.3
ClO	0.1	-.-	-.-
SO3	0.2	-.-	-.-
OXYGEN	7.7	7.3	2.9
TOTAL	100.0	100.0	100.0
SI	5.57	9.28	0.02
AL	2.18	4.49	-.-
Fe	2.40	0.04	1.8
Mg	1.16	0.03	0.01
Ca	1.66	1.09	0.01
Na	0.40	2.10	-.-
K	0.06	-.-	-.-
Ti	0.01	-.-	1.79
P	-.-	-.-	-.-
Mn	-.-	-.-	0.05
Cl	0.01	-.-	-.-
S	0.02	-.-	-.-
O	24.0	32.0	6.0
AR=	32.6	Ab 65.8 An 34.2	
Name	Tschermikite	Andesine	Ilmenite

AR - amphibole ratio

These regions usually have an overall elliptical shape that may approximate an olivine cross-section parallel to (100) or a pyroxene crystal normal to (010). A less common relict shape that the opaques take is exhibed in figure 8. Here, the opaque pseudomorph resembles an olivine or pyroxene crystal more closely. The opaques are predominantly ilmenite (Table 3) with minor pyrite, pyrrhotite and magnetite. The remainder of the minerals of unit 2 consist of minor amounts of polycrystalline pods (amygdales) and stringers of quartz, chlorite (penninite) fracture fillings, sericite alteration, and secondary calcite, limonite and hematite.

The unit 2 mineral assemblage of blue-green hornblende + plagioclase (An_{34}) + quartz + opaques (ilmenite and magnetite) + epidote ± muscovite ± calcite represents the albite-epidote amphibolite metamorphic facies of Williams, Turner and Gilbert (1954).

The unit is also generally quartz-normative (Table 4) and tholeiitic (Figure 9).

3.1.2 Cockeram Lake Aphyric Andesite (subunit 2a)

Subunit 2a is by far the most widespread unit within the Cockeram Lake section. Of a total of twelve outcrops sampled, seven are andesitic.

Features distinguishing subunit 2a from 2b and 2c are:

1. These rocks are normative quartz andesites and andesites.

TABLE 4

Normalized Chemical Analysis, CIPW Normative Mineralogy, and Normative Color Index of Cockeram Lake Aphyric Basalt and Andesite (unit 2).

UNIT	2a	2a	2b	2b	2c	2c
SAMPLE	062	038	014	121	039	037
SiO2	53.16	52.21	52.19	53.73	50.88	50.57
Al2O3	14.06	14.15	15.19	14.66	18.13	18.92
Fe2O3	2.91	3.13	2.51	3.05	2.46	2.48
FeO	11.14	11.62	8.25	10.83	7.77	7.54
CaO	8.69	7.89	10.85	8.76	10.57	9.89
MgO	4.73	5.32	6.33	4.05	5.51	5.38
Na2O	3.15	3.19	3.00	2.67	2.98	3.40
K2O	0.40	0.40	.035	0.27	0.53	0.61
TiO2	1.38	1.56	0.96	1.51	0.90	0.93
P2O5	0.18	0.27	0.17	0.27	0.08	0.10
MnO	0.24	0.25	0.21	0.22	0.18	0.18
Cu	15.0	25.0	50.0	170.	78.0	21.0
Ag	< .5	< .5	< .5	< .5	< .5	< .5
Au	24.	<2.	<2.	7.	2.	7.
Zn	42.0	56.0	17.0	21.0	18.0	26.0
Y	20.	30.	10.	30.	20.	30.
Pb	2.	<2.	6.	2.	4.	6.
Zr	70.	50.	40.	90.	40.	50.
As	3.	1.	6.	1.	2.	4.
Sb	.4	.5	1.3	.9	2.1	1.6
V	430.	520.	260.	480.	250.	240.
Cr	31.	41.	62.	34.	51.	48.
Mo	3.0	2.5	4.5	2.0	3.0	3.5
Co	8.0	14.0	9.5	10.0	11.0	9.5
Ni	3.5	9.5	17.0	5.0	9.0	10.0
QZ	5.04	3.58	1.35	9.31	-.-	-.-
OR	2.37	2.35	2.08	1.58	3.12	3.24
AB	26.31	26.97	25.36	22.56	25.25	27.67
AN	23.22	23.14	26.96	27.26	34.52	36.23
DI	15.63	11.88	21.14	12.12	14.27	9.40
HY	20.16	23.94	17.27	19.28	16.18	8.14
OL	-.-	-.-	-.-	-.-	1.19	9.66
MT	4.23	4.53	3.64	4.42	3.56	3.63
IL	2.61	2.97	1.83	2.86	1.71	1.81
AP	0.44	.65	0.39	0.63	0.20	0.22
CI	43.64	43.33	43.88	38.68	36.9	33.64

Figure 7: Photomicrograph of ilmenite assuming a "relict" morphology of olivine or pyroxene from Cockeram Lake aphyric basalt sample 121. White areas are anhedral plagioclase grains. Plane polarized light, 88x.

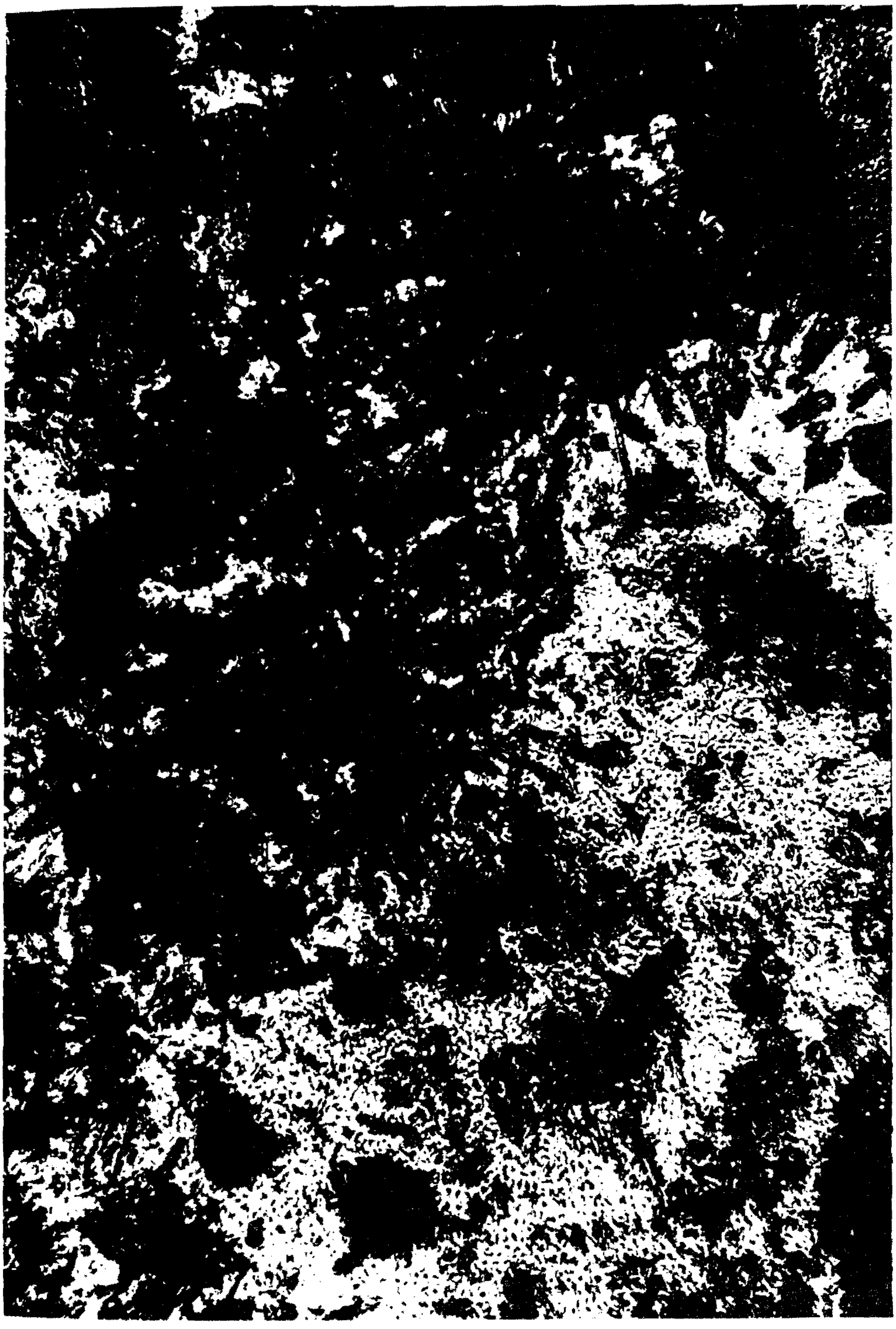


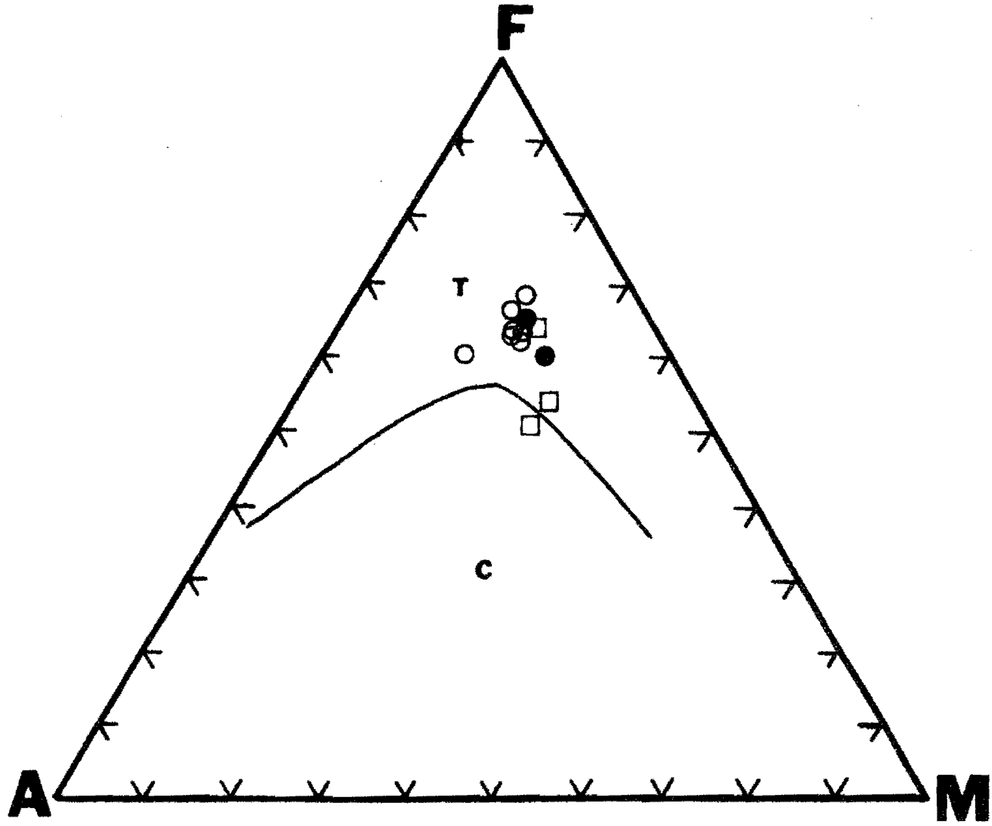
Figure 8: Photomicrograph of "relict" opaque of Cockeram Lake basalt sample 121. Veins cutting the sample are quartz. Plane polarized light, 50x.

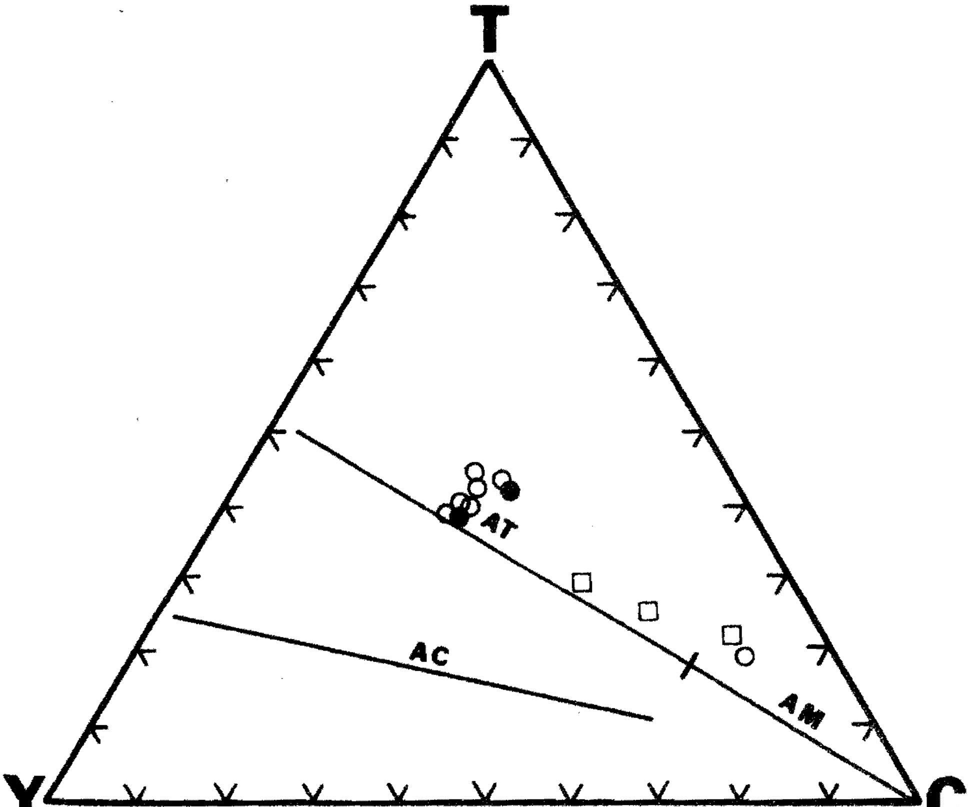
Figure 9: AFM and YTC plots for unit 2 sample
A = $Na_2O + K_2O$, F = FeO + 0.8998(Fe_2O_3), M = MgO, al
expressed in weight percent. Y = Y + Zr (ppm), T
TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram i
divided into tholeiitic (T) and calc-alkaline (C
fields after Irvine and Barager (1971) and the YT
diagram has Archean tholeiitic (AT), Archean magnesia
(AM) and Archean calc-alkaline (AC) basalt trend
delimited after Davies et al. (1979).

○ Cockeram Lake aphyric andesite (subunit 2a)

● Cockeram Lake aphyric basalt (subunit 2b)

□ Cockeram Lake amygdaloidal basalt (subunit 2c)


F
T
C
A
M


T
AT
AC
AM
Y
C

2. There is a greater amount of modal quartz and opaques and less amphibole (Table 2).
3. Epidotization is not as common.
4. Very minor occurrences of porphyritic andesine occur, as well as minor polycrystalline fine-grained amygdales. Generally, the groundmass appears hornfelsic to slightly gneissic.
5. There are higher Zn and V contents (Table 4).
6. There is higher normative albite and hypersthene and lower normative anorthite (Table 4).

3.1.3 Cockeram Lake Aphyric Basalt (subunit 2b)

Unit 2b occurs in subordinate amounts; only two of the twelve unit 2 outcrops are of this type.

Features that aid in distinguishing subunit 2b from other unit 2 rock types are:

1. These rocks are normative basalts and tholeiitic basalts.
2. Modally less plagioclase and more amphibole are present (Table 2).
3. Epidotization is more common, with patches of epidosite common in outcrop.
4. The rock always appears aphyric with a hornfelsic texture.
5. There are lower K_2O contents (Table 4).

6. The normative anorthite content is usually around 26-27% and normative diopside is usually high (up to 21%) (Table 4).

3.1.4 Cockeram Lake Amygdaloidal Basalt (subunit 2c)

Subunit 2c also occurs in subordinate amounts; three of twelve unit 2 outcrops are of this type.

Distinguishing characteristics are:

1. The most obvious feature is the amygdaloidal (up to 20%) nature of the outcrop with amygdale sizes ranging up to .5cm. Densely amygdaloidal flow tops can at times be distinguished on outcrop surfaces.
2. In thin section, the amygdales are common features. Both polycrystalline quartz fillings and polymineralic quartz, plagioclase, calcite and chlorite fillings are common.
3. There is a very low modal quartz content when the amygdales are removed from consideration. Plagioclase is more abundant than in the other two units and micas are also more common. Opaques are much rarer (Table 2).
4. Epidotization and epidosite is much more common than in subunit 2b.
5. Unit 2c is lower in SiO_2, P_2O_5, Zr, and V but higher in Al_2O_3, K_2O and Sb (Table 4).

6. This unit is unique in that it has normative olivine. A higher normative orthoclase and anorthite, with lower normative apatite and color index (Table 4) also sets this unit apart from the others.

3.1.5 McVeigh Lake Porphyritic Basalt and Andesite (unit 3)

3.1.5.1 Occurrence

The McVeigh Lake porphyritic basalt and andesite unit represents one of the least extensive and most poorly exposed units of volcanic rocks within the map area. The unit is found predominantly within the northern section of the Rabbit's claim. There are also minor occurrences just south of the Luck claim, along the western Wasekwan Lake shoreline.

In the Rabbit's claim, unit 3 is in contact with the Cockeram Lake basalts and andesites (unit 2) to the south. Where unit 2 pinches out, the McVeigh Lake unit has a southern contact with the Fraser Lake volcanic rocks (unit 4) and there are several occurrences of the McVeigh Lake volcanic rocks within the Fraser Lake unit. Minor occurrences of the Fraser Lake-Eldon Lake sedimentary section (unit 9) are found within unit 3. In the southern portion of the Rabbit's claim, unit 3 is found between the Fraser Lake volcanic rocks to the north and west and the Fraser Lake-Eldon Lake sedimentary rocks to the south and east.

Outcrops of unit 3 are found just south of the Luck claim. Here, intense folding, veining and shearing occurred, indicating that the exposure's relationship to the units north of it is probably structural and that it was probably drag-folded or fault-emplaced into its present position.

Structurally, the McVeigh Lake volcanic rocks in the northern portion of the Rabbit's claim are in the core of the McVeigh Lake Anticline (Gilbert et al. 1980). There also appears to be some structural folding of the McVeigh Lake volcanic rocks around the Fraser Lake-Eldon Lake sedimentary unit in the southern portion of the Rabbit's claim.

As previously noted, the occurrences south of the Luck claim were structurally emplaced and are probably related to the Cartwright Lake shear zone directly to the north.

Gilbert et al. (1980) report that the McVeigh Lake volcanic rocks appear to have been extruded about the same time as the Cockeram Lake suite, as indicated by the intercalation of the two suites. This study shows that the McVeigh Lake volcanic rocks are similarly related to the Fraser Lake volcanic rocks (unit 4) to the west, with the same type of interfingering of the two units.

3.1.5.2 Field Observations

The McVeigh Lake basalts and andesites are generally medium grey to light grey-green on a weathered surface. The exposures surface appears rather rounded with angular sides and fair to poorly developed jointing surfaces. The rock usually has a fine-grained matrix but also has very distinct and moderately abundant medium-grained hornblende pseudomorphs after pyroxene (averaging 20%). Some outcrops contain fine- to medium-grained plagioclase phenocrysts (less than 10%). Quartz stringers and sulfides are usually rare but minor calcite does occur. Although rare pillows are reported in the literature, none are noted. Very minor occurrences of tuffaceous units are found sporadically, as well as occasional monolithic breccias with clasts measuring up to 6.4 x 12.7 centimeters and averaging 20% of the rock volume.

Unit three has been divided into three members; porphyritic andesite (subunit 3a), porphyritic basalt (subunit 3b) and porphyritic andesitic breccia (subunit 3c).

3.1.5.3 Mineralogy and Chemistry

The typical unit 3 mineralogy (Table 5) involves a high percentage of bimodally sized amphiboles. One size population is composed of fine-grained (to .38mm), euhedral to subhedral, fibrous, blue-green pleochroic hornblende. This amphibole forms a strong lineation and predates later structural crenulations. Microprobe analysis (Table 6) shows this amphibole to be of a common hornblende composition. The second size population consists of medium-grained (to

2.2mm), anhedral to subhedral, amphibole porphyroblasts that are pseudomorphic after pyroxene phenocrysts and have a slight glomeroporphyritic tendency. These amphiboles have a blue-green pleochroism, epidote and quartz poikiloblasts and are usually slightly chloritized. Their external morphology is that of a pyroxene, yet their cleavage fracture is largely amphibole. Some of the cores of the larger grains are not optically continuous and may be highly altered (chloritized and uralitized) pyroxene remnants. Pyroxene twinning and exsolution lamellae are preserved. The porphyroblastic amphibole composition is within the hastingsite range.

Unit 3 also contains substantial amounts of plagioclase, with a bimodal distribution again evident. The majority of plagioclase is fine-grained (to .35mm) and occurs as an anhedral, annealed, mosaic groundmass which contains untwinned, slightly sericitized and more intensly saussuritized plagioclase. Microprobe analysis shows a predominant albite (Ab_{90}) composition (Table 6). The second size distribution contains medium- to coarse-grained (to 2.12mm), anhedral, albite-, Carlsbad- and polysynthetically-twinned plagioclase. Normal zoning, overgrowths, and poikiloblastic epidote and mica are also found within these plagioclases. Microprobe analysis gives a composition of An_{45} (andesine) (Table 6). Sericitization is very intense and epidote is quite common, particularly along the feldspar twin planes.

TABLE 5

Point Counted Modes and Average, Visually Estimated Modes of McVeigh Lake Volcanic Rocks (unit 3)

UNIT	3a	3a	3a	3b	3b	3b	3c
SAMPLE	076	114	$\bar{X}$ N=3	060	064	$\bar{X}$ N=4	$\bar{X}$ N=1
Quartz	2.6	2.0	3.9	1.0	6.6	1.58	6.0
Plagioclase	54.2	34.8	43.0	12.8	10.8	10.8	42.0
White Mica	-.-	5.6	2.2	.6	-.-	.16	-.-
Chlorite	-.-	pr.	.07	-.-	.8	2.72	10.0
Amphibole	22.4	42.8	35.1	83.0	79.6	80.04	37.0
Epidote	12.6	14.8	10.8	1.8	1.4	1.48	3.0
Carbonate	8.0	pr.	3.0	-.-	pr.	3.2	1.0
Opaque	.2	-.-	.07	.8	.8	.88	1.0

$\bar{X}$ - mean
pr. - present

TABLE 6

Typical Chemical Composition of Minerals of Subunits 3a and 3b

SAMPLE	AMPH	AMPH	PLAG	PLAG	OPAQUE	EPIDOTE
SiO2	41.0	41.8	64.2	56.3	0.3	37.5
Al2O3	15.4	11.8	20.3	25.6	0.2	24.1
FeO	13.5	19.0	0.3	0.1	44.9	10.4
MgO	8.0	7.0	0.1	0.2	0.2	-.-
CaO	11.7	11.9	1.7	8.4	0.3	24.1
Na2O	1.9	1.1	8.8	5.7	-.-	0.3
K2O	0.2	0.4	-.-	0.0	-.-	-.-
TiO2	0.6	0.3	-.-	-.-	51.8	0.1
P2O5	-.-	-.-	-.-	-.-	-.-	-.-
MnO	0.2	0.6	-.-	-.-	2.8	0.1
ClO	0.1	-.-	0.1	-.-	-.-	-.-
SO3	-.-	-.-	0.1	-.-	-.-	-.-
OXYGEN	6.7	6.2	4.4	3.7	0.2	3.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
SI	5.65	5.93	10.71	9.66	0.01	2.93
AL	2.50	1.97	3.99	5.17	0.01	2.23
FE	1.55	2.26	0.04	0.02	1.86	0.68
MG	1.79	1.49	0.03	0.05	0.01	-.-
CA	1.73	1.80	0.31	1.54	0.01	2.02
NA	0.52	0.31	2.86	1.89	-.-	0.02
K	0.04	0.07	-.-	0.01	-.-	-.-
TI	0.06	0.04	-.-	-.-	1.95	0.01
P	-.-	-.-	-.-	-.-	-.-	-.-
MN	0.03	0.07	-.-	-.-	0.12	0.01
CL	0.02	-.-	0.24	-.-	-.-	-.-
S	-.-	-.-	0.01	-.-	-.-	-.-
O	24.0	24.0	32.0	32.0	6.0	13.0
AR=	53	39	Ab 90.3 An 9.7	Ab 54.9 An 44.8		
NAME	Hastingsite	Hornblende	Albite	Andesine	Ilmenite	Epidote

AR - amphibole ratio

Epidote is the next most abundant mineral, the majority occurs as fine-grained, anhedral, granular grains associated with the plagioclase-rich areas. Only rarely is epidote found with quartz veins, calcite or chlorite. Some epidote does appear to be included in veins that crosscut the amphiboles. Microprobe analysis (Table 6) indicates an epidote composition for the grains.

Quartz occurs within the fine-grained groundmass mosaic and can be distinguished by its lack of sericitization. Minor polycrystalline quartz veins are are present.

Muscovite, chlorite (penninite), and calcite occasionally occur in small amounts. When opaques are found, they are most often fine-grained, anhedral, ilmenite grains.

Unit 3 mineralogy, consisting of blue-green amphibole + plagioclase (An_{10}) + quartz + epidote $\pm$ opaques (ilmenite) $\pm$ muscovite $\pm$ calcite again represents the albite-epidote amphibolite metamorphic facies of Williams, Turner and Gilbert (1954).

The unit is generally quartz-normative (Table 7) but exceptions are present and will be noted below. Figure 10 demonstrates that most analyses fall within the calc-alkaline field on the AFM diagram and within the Archean tholeiitic and magnesian field on the YTC diagram. This apparent discrepancy arises from the metasomatic history of the rocks. High K_2O analyses for unit 3 (approximately 1%) are noteworthy, as is the abundance of untwinned albite. Both demonstrate a potassium and sodium metasomatic history. Gilbert et al. (1980) also note a high K_2O content in their analyses and attribute it to potassium metasomatism. This process renders the AFM diagram less reliable; therefore, by emphasizing the YTC diagram, an Archean tholeiitic and magnesian character for the unit is presumed to be more accurate.

3.1.6 McVeigh Lake Porphyritic Andesite (subunit 3a)

Of nine unit 3 outcrops sampled, four proved to be andesitic; three of these are porphyritic.

Distinguishing features of subunit (3a) rocks are:

1. The rocks are normative quartz andesites and quartz latite andesites.
2. There is more modal plagioclase (mean=43%) and less amphibole (mean=35.1%) than the unit 3 basaltic rocks. The rocks also appear more highly epidotized (mean=10.8%) and, except for one thin section, the rocks contain no opaques (Table 5).
3. The rocks always contain pseudomorphic hornblende after pyroxene glomerophenocrysts and always have medium-grained plagioclase porphyroblasts.
4. A gneissic structure is always developed and rare polycrystalline quartz amygdales are present.
5. They contain the highest K_2O contents (about 1%) of unit 3 samples and higher SiO_2 (greater than 55.5%),

TABLE 7

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of McVeigh Lake Volcanic Rocks (unit 3)

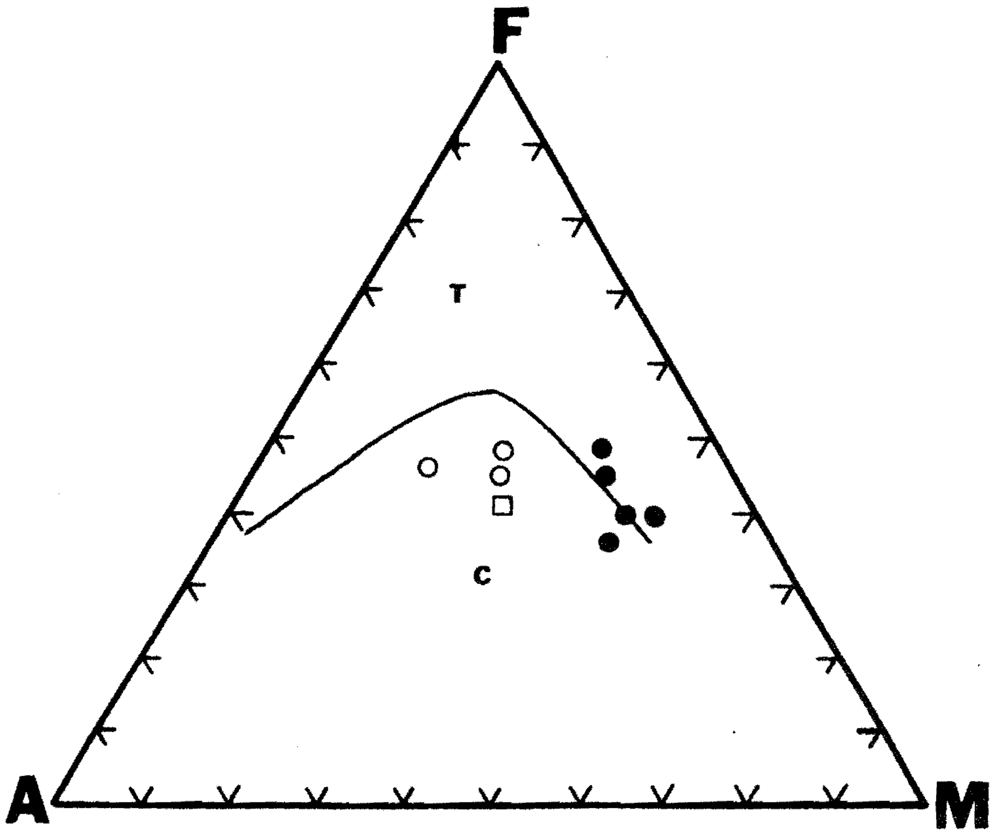
UNIT	3a	3a	3b	3b	3c
SAMPLE	076	117	060	92	107
SiO2	59.74	56.06	52.8	47.66	54.11
Al2O3	14.8	15.5	13.23	11.36	16.59
Fe2O3	2.45	2.32	2.22	2.27	2.46
FeO	4.51	6.96	8.06	8.08	5.60
CaO	9.59	8.84	10.87	14.33	8.85
MgO	2.49	4.89	8.90	13.06	5.99
Na2O	4.06	3.37	2.47	1.86	4.23
K2O	0.92	0.64	0.41	0.31	0.88
TiO2	1.04	0.76	0.69	0.68	0.93
P2O5	0.24	0.16	0.13	0.17	0.22
MnO	0.15	0.17	0.22	0.23	0.15
Cu	29.0	13.0	17.0	21.0	200.
Ag	.5	<.5	<.5	<.5	<.5
Au	<2.	<2.	2.	<2.	5.
Zn	55.0	37.0	17.0	16.0	35.0
Y	20.	-.-	20.	-.-	20.
Pb	6.	4.	<2.	6.	4.
Zr	70.	80.	30.	20.	60.
As	7.	1.	2.	<1.	18.
Sb	1.4	1.0	1.1	.8	1.6
V	290.	220.	300.	220.	270.
Cr	120.	200.	202.	1210.	92.
Mo	5.0	3.0	1.5	5.0	2.0
Co	9.0	13.0	6.5	8.0	16.0
Ni	5.0	13.0	8.0	31.0	17.0
QZ	12.53	6.38	1.43	-.-	-.-
OR	5.46	5.84	2.42	1.82	5.21
AB	34.38	28.51	20.91	11.64	35.79
AN	19.43	24.24	23.79	21.74	23.67
NE	-.-	-.-	-.-	2.21	-.-
DI	21.79	15.28	23.76	38.71	15.22
HY	0.32	14.57	22.86	-.-	13.59
OL	-.-	-.-	-.-	18.85	0.69
MT	3.55	3.36	3.23	3.29	3.59
IL	1.97	1.44	1.30	1.29	1.77
AP	0.57	0.37	0.32	0.40	0.52
CI	27.63	34.66	51.14	62.20	34.83

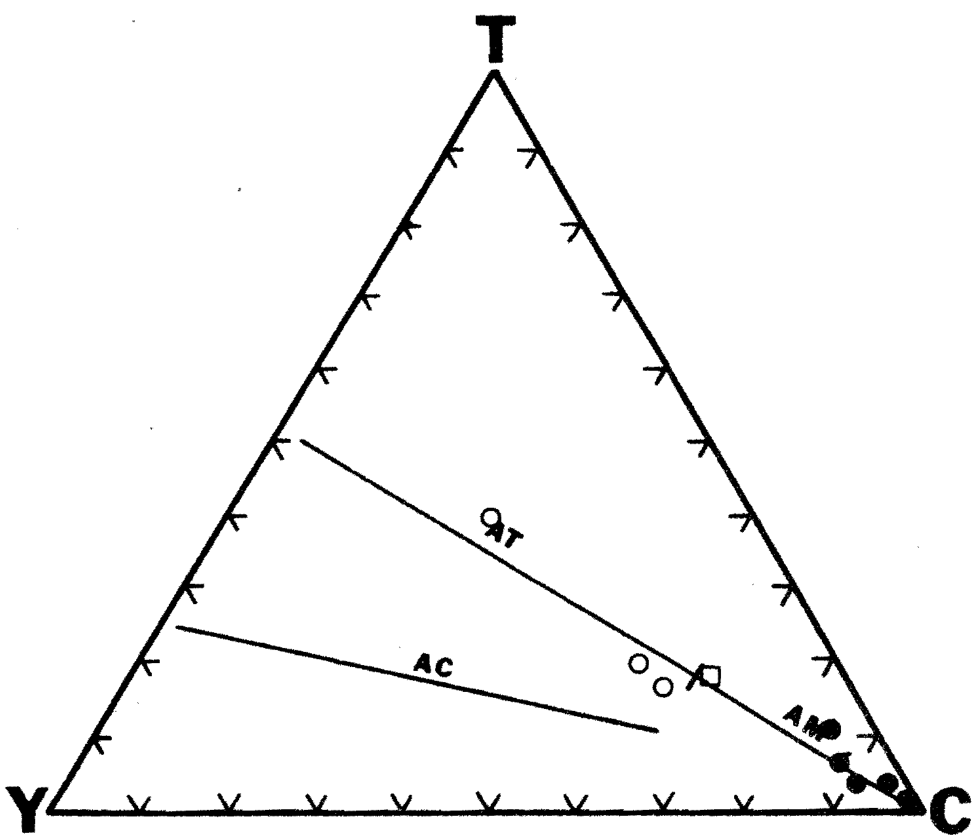
Figure 10: AFM and YTC plots for unit 3 sampl
A = $Na_2O + K_2O$, F = FeO + 0.8998(Fe_2O_3), M = MgO, expressed in weight percent. Y = Y + Zr (ppm), TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram divided into tholeiitic (T) and calc-alkaline fields after Irvine and Barager (1971) and the diagram has Archean tholeiitic (AT), Archean magnes (AM) and Archean calc-alkaline (AC) basalt tre delimited after Davies et al. (1979).

○ McVeigh Lake porphyritic andesite (subunit 3a)

● McVeigh Lake porphyritic basalt (subunit 3b)

□ McVeigh Lake porphyritic andesite breccia (subu 3c)


F
T
C
A
M


T
AT
AC
Y
C

TiO_2 (greater than .72%), Zn (greater than 37ppm) and Zr (greater than 40ppm) (Table 7).

6. High normative quartz (greater than 5.3%), orthoclase (greater than 5.46%), albite (greater than 26.05) and a relatively low normative color index (less than 34).
7. Analyses fall within the Archean tholeiitic trend on the YTC diagram (Figure 10).

3.1.7 McVeigh Lake Porphyritic Basalt (subunit 3b)

Four of nine outcrops are of this member. Features that discriminate subunit 3b rocks from subunits 3a or 3c are:

1. Based on normative minerals, this unit is composed of basalt and latite basalt.
2. Less modal quartz (mean=1.58%), plagioclase (mean=10.8%) and mica (mean=.16) with much more amphibole (mean=80.04%) and opaques (mean=.88%) (Table 5) occur.
3. These rocks contain pyroxene pseudomorphs but do not usually contain plagioclase porphyroblasts.
4. Epidotization is less common
5. The texture developed is more schistose than gneissic and no amygdales or breccias are present.
6. The major oxides that have low values are: SiO_2 (less than 53%), TiO_2 (less than .99%), and K_2O (less

than .84%). Higher values are found with: FeO (greater than 5.0%), CaO (greater than 10.3%), and MgO (greater than 8.4%) (Table 7).

7. Lower Zn (less than 35ppm), Zr (less than 60ppm), Co (less than 16ppm) and very high Cr (greater than 270ppm) contents.
8. Lower normative quartz (less than 1.4%) occurs with some of the analyses, yielding normative nepheline or high normative olivine (greater than 8.85%). A high normative color index (greater than 50) also results (Table 7).

3.1.8 McVeigh Lake Porphyritic Breccia (subunit 3c)

One of nine unit 3 samples is of this type. Chemically, this rock is an andesite with many features similar to those of subunit 3a. A few minor differences did exist:

1. This rock is consistently a normative andesite.
2. This occurrence has higher Cu and Ni contents than subunit 3a (Table 7).
3. This unit is slightly olivine-normative (.69%) (Table 7).
4. The presence of highly chloritized and biotized breccia clasts is the most distinct feature.
5. Texturally, this rock is more schistose than those of subunit 3a.

The rock contains the pyroxene pseudomorphs characteristic of subunit 3a but has no plagioclase porphyroblasts. Due to the above features and the similarity of points on the AFM and YTC diagrams, this rock seems to be closer genetically to the McVeigh Lake andesite members than the basalt members.

3.1.9 Fraser Lake Mafic Volcanic Body (unit 4)

3.1.9.1 Occurrence

The Fraser Lake mafic volcanic body represents the largest volume of volcanic rocks within the map area. The unit occupies most of the central Rabbit's claim as well as the central portions of Good, Luck and Tornado claims. Scattered outcrops occur in the Mirage claim.

Within the Rabbit's claim, the Fraser Lake mafic volcanic rocks are in contact with the McVeigh Lake body (unit 3) to the northwest and south and with the Cockeram Lake volcanic body (unit 2) to the north and east. In the southeast, there is a contact with the Fraser Lake-Eldon Lake sedimentary section (unit 9). The southern boundary follows an extensive granodiorite sill (unit 17) and in the southwest portion of Good, unit 4 can be found south of this sill. The western portion of unit 4, within the Good claim, intercalates with the Fraser Lake-Eldon Lake sedimentary section (unit 9); the eastern portion of unit 4, within the Tornado claim, interfingers with the intermediate and felsic rocks of the Pole Lake area (unit 5). Some unit 4 rocks occur within the unit 5 body; these will be discussed in detail below.

Structurally, the unit may have been thickened by drag-folding as the dextral-slip Cartwright Lake shear zone is near the southern boundary of most of this unit.

Gilbert et al. (1980) state that this mafic volcanic body is laterally equivalent to the central portion of the Fraser Lake sedimentary section (unit 9); this would account for the intercalating of the two units near their margins.

3.1.9.2 Field Observations

The Fraser Lake mafic volcanic body is composed predominantly of intermediate and mafic flows and tuffs. At times, many are intimately intermixed. The mafic flows and tuffs appear darker grey and green-grey on weathered surface than do the intermediate flows and tuffs, which exhibit a medium grey color. Most hand specimens are aphanitic but occasionally the amphiboles are large enough to be observed, as are occasional plagioclase crystals.

Unless the area is highly metamorphosed or sheared, tuffaceous units can be distinguished from those of flows. In most cases, the tuffs are finely laminated. This lamination occurs as a fine, discontinuous banding that is well crenulated and weathers so that the more resistant layers are in relief. Foliation is pronounced but may be difficult to measure due to intense crenulation. The flows appear homogeneous and have weathered into blocky and angular outcrops. The very fine-grained, homogeneous nature of these rocks also prevents any foliation measurments.

Throughout this unit, calcite and quartz stringers up to 2.5 cm wide can occur. Magnetite, as well as the sulfides pyrite and pyrrhotite, are found in relatively rare instances. The unit is commonly sheared, giving rise to chlorite- and calcite-rich zones. Unit 4 has been divided into seven members: aphyric andesite flows (subunit 4a), aphyric basalt flows (subunit 4b), amygdaloidal aphyric basalt (subunit 4c), amygdaloidal basalt (subunit 4d), porphyritic basalt (subunit 4e), mafic tuff (subunit 4f), highly altered chemically mafic tuff (subunit 4fa) and intermediate tuff (subunit 4g).

3.1.9.3 Mineralogy and Chemistry

The typical unit 4 mineralogy (Tables 8-10) contains a high proportion of fine-grained (to .44mm) and some coarse-grained (up to 2.2mm), subhedral, fibrous, blue-green pleochroic amphibole. Poikiloblasts of plagioclase, quartz and opaques can be found. The amphiboles are generally not oriented in one direction. Microprobe analysis (Table 11) shows a preponderance of tschermakitic hornblende. Within highly altered areas, hornblende is completely absent, having been replaced by chlorite. Unit 4 also contains a large population of plagioclase. The two most common occurrences are as fine-grained, anhedral, untwinned, mosaic groundmass, and as fine- to medium-grained (to 1mm), porphyroblastic, albite-twinned, anhedral "clots", probably representing original phenocrysts with overgrowths. Sericite and epidote alteration is common. Anorthite content determined optically is approximately An_{30}. Analysis by microprobe also gives values within the andesine compositional range, varying from An_{30} to An_{40}.

Quartz is another common mineral that usually occurs as stringers and veins or as a fine-grained (.2mm), anhedral mosaic groundmass intimately intermixed with plagioclase. The absence of alteration is the best optical indicator of its presence.

Opaques again are common, particularly in the volcanic flow units. They usually exhibit an anhedral morphology and appear to be remnants of primary grains. They are usually fine-grained (to .1mm) and anhedral, but medium-grained (to 1mm) euhedral grains are not uncommon. The euhedral grains probably represent secondary mineralization. Pyrite appears as fine-grained, anhedral crystals if primary or as euhedral cubes if secondary. Ilmenite also is occasionally anhedral but usually takes the form of fine-grained, flat, bladed crystals. Magnetite is usually secondary and shows a hexagonal crystal outline.

TABLE 8

Point Counted Modes and Average, Visually Estimated Modes of Fraser Lake Mafic Volcanic Subunits 4a, 4b, 4c

UNIT	4a	4a	4a	4b	4b	4b	4c	4c	4c
SAMPLE	054	145A	$\bar{X}$ N=3	090	120	$\bar{X}$ N=3	016	113	$\bar{X}$ N=2
Quartz	5.6	1.6	4.1	1.0	.2	5.4	1.8	10.0	5.9
Plagioclase	51.8	43.4	43.4	27.6	14.0	14.2	33.4	63.6	48.5
White Mica	6.8	pr.	2.3	pr.	pr.	.07	pr.	1.0	.5
Chlorite	3.6	pr.	1.3	-.-	8.8	2.9	3.8	18.2	11.0
Amphibole	-.-	49.4	35.5	67.8	75.2	73.7	58.0	-.-	29.0
Epidote	pr.	1.0	.4	-.-	-.-	-.-	.2	-.-	.1
Carbonate	24.2	-.-	8.4	pr.	-.-	1.0	pr.	2.6	1.3
Opaque	8.0	4.6	4.9	3.6	.2	2.3	2.8	4.0	3.4
Biotite	-.-	-.-	-.-	-.-	-.-	-.-	-.-	.6	.3

$\bar{X}$ - mean
pr. - present

TABLE 9

Point Counted Modes and Average, Visually Estimated Modes of Fraser Lake Mafic Volcanic Subunits 4e, 4f, 4fa

UNIT	4e	4e	4e	4f	4f	4fa	4fa	4fa
SAMPLE	082	084	X N=3	058	X N=3	003	008	X N=8
Quartz	5.8	14.0	6.6	-.-	2.3	29.0	1.6	21.2
Plagioclase	35.2	31.6	27.3	37.4	46.5	4.2	21.0	23.15
White Mica	.2	pr.	.1	pr.	8.7	.8	27.6	13.31
Chlorite	-.-	pr.	.03	5.8	3.9	34.8	-.-	14.0
Amphibole	53.4	36.4	56.6	44.0	31.3	-.-	-.-	.01
Epidote	pr.	.2	.1	11.4	6.1	12.6	49.8	13.6
Carbonate	-.-	14.4	5.1	.2	.1	14.8	pr.	12.1
Opaque	5.4	3.4	4.3	1.2	1.1	3.8	pr.	2.1
Apatite	-.-	-.-	-.-	-.-	-.-	-.-	pr.	.01
Tourmaline	-.-	-.-	-.-	-.-	-.-	-.-	-.-	pr.

X - mean
pr. - present

TABLE 10

Point Counted Modes and Average, Visually Estimated Modes of Fraser Lake Mafic Volcanic Subunit 4g

UNIT	4g	4g	4g
SAMPLE	078	091	$\bar{X}$ N=3
Quartz	1.4	-.-	1.1
Plagioclase	35.2	39.4	41.9
White Mica	-.-	pr.	.1
Chlorite	1.6	.4	.7
Amphibole	55.8	57.4	51.1
Carbonate	2.8	pr.	1.0
Opaque	3.2	2.8	3.0

$\bar{X}$ - mean
pr. - present

TABLE 11

Typical Chemical Compsition of Unit 4 Minerals

SAMPLE	AMPHIBOLE	PLAGIOCLASE	CHLORITE	OPAQUE	OPAQUE
SiO2	39.9	59.0	22.3	0.1	0.3
Al2O3	13.6	25.0	21.0	-.-	0.2
FeO	19.9	0.3	28.5	32.2	43.2
MgO	5.6	0.1	8.9	-.-	-.-
CaO	11.4	7.5	0.1	0.0	0.2
Na2O	1.6	6.3	0.2	0.1	-.-
K2O	0.3	-.-	-.-	0.0	-.-
TiO2	0.2	-.-	-.-	-.-	49.4
P2O5	-.-	-.-	0.1	-.-	-.-
MnO	0.2	-.-	-.-	-.-	3.19
ClO	0.1	-.-	0.1	-.-	-.-
SO3	-.-	-.-	0.1	67.6	0.1
OXYGEN	7.2	2.0	18.7	-.-	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0
SI	5.62	10.27	4.22	-.-	0.1
AL	2.26	5.12	4.71	-.-	0.1
FE	2.35	0.04	4.53	-.-	1.71
MG	1.17	0.03	2.51	-.-	-.-
CA	1.73	1.39	0.02	-.-	0.01
NA	0.44	2.12	0.08	-.-	-.-
K	0.06	-.-	-.-	-.-	-.-
TI	0.02	-.-	-.-	-.-	-.-
P	-.-	-.-	0.02	-.-	-.-
MN	0.03	-.-	-.-	-.-	0.13
CL	0.02	-.-	0.04	-.-	-.-
S	0.0	-.-	0.01	-.-	-.-
O	24.0	32.0	36.0	-.-	6.0
AR=	33.1	Ab 60.4 An 39.6			
NAME	Tschermakite	Andesine	Ripidolite	Pyrite	Ilmenite

AR - amphibole ratio

A mineral that is commonly found in trace amounts in most of unit 4, but can also occur in major amounts (up to 35%), is chlorite. It is commonly fine-grained, subhedral to anhedral and of the pleochroic, "Berlin blue" variety (penninite). Microprobe analyses indicate that the compositions fall within the ripidolite class (Table 11). This chlorite is always found in moderately to highly altered rocks.

Minerals that occur throughout unit 4 but only in trace amounts are epidote, biotite, muscovite, apatite and zircon.

Unit 4's mineralogy changes laterally. It progresses from blue-green amphibole + plagioclase (An_{39}) + quartz + opaques (ilmenite, magnetite and pyrite) + epidote $\pm$ muscovite $\pm$ calcite in the west, representing the albite-epidote amphibolite facies, to chlorite (penninite) + quartz + calcite + epidote plagioclase (An_{30}) + opaques (pyrite, ilmenite and magnetite) + muscovite, representing the greenschist facies in the east. The unit is generally quartz-normative (Tables 12-14) and tholeiitic (Figure 11).

3.1.10 Fraser Lake Aphyric Andesite (subunit 4a)

Eight of twenty-six samples collected from the Fraser Lake mafic body are andesitic in composition. Of the eight, three are aphyric andesite flows.

Distinguishing features of this unit are:

TABLE 12

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Fraser Lake Mafic Volcanic Subunits 4a, 4b and 4c

UNIT	4a	4a	4b	4b	4c	4c
SAMPLE	054	056	090	116	016	113
SiO2	56.95	52.33	52.73	49.29	52.67	60.01
Al2O3	14.13	15.00	15.07	16.82	14.80	17.43
Fe2O3	3.02	2.67	2.48	2.33	2.78	2.57
FeO	9.16	8.72	9.29	8.73	10.16	7.55
CaO	6.16	9.61	9.61	13.09	8.81	3.64
MgO	4.39	6.38	6.10	4.84	5.60	3.22
Na2O	3.74	3.07	3.08	3.15	3.06	3.97
K2O	0.44	0.68	0.36	0.21	0.54	0.34
TiO2	1.48	1.10	0.93	1.27	1.23	1.00
P2O5	0.32	0.22	0.15	0.09	0.12	0.15
MnO	0.20	0.22	0.21	0.17	0.23	0.13
Cu	61.0	150.	150.	51.0	63.0	180.
Ag	<.5	.5	<.5	<.5	.5	.5
Au	<2.	15.	6.	10.	4.	<2.
An	35.0	40.0	19.0	16.0	31.0	95.0
Y	20.	20.	20.	10.	10.	20.
Pb	<2.	6.	4.	8.	4.	<2.
Zr	90.	30.	30.	50.	70.	90.
As	1.	4.	4.	26.	2.	4.
Sb	.7	.7	1.6	.6	2.4	.7
V	190.	330.	310.	350.	310.	140.
Cr	100.	55.	44.	99.	48.	27.
Mo	2.5	4.5	3.0	6.0	3.0	<.5
Co	10.0	14.0	8.0	25.0	8.5	26.0
Ni	3.0	18.0	11.0	39.0	3.5	<.5
QZ	10.77	1.29	2.32	-.-	3.06	18.72
CO	-.-	-.-	-.-	-.-	-.-	4.26
OR	2.62	4.03	2.13	1.26	3.18	2.04
AB	31.69	26.00	26.02	25.58	25.92	33.56
AN	20.44	25.11	26.24	31.12	25.04	17.12
NE	-.-	-.-	-.-	0.59	-.-	-.-
DI	6.66	17.32	16.84	27.56	14.79	-.-
HY	19.89	19.78	20.74	-.-	21.36	18.35
OL	-.-	-.-	-.-	7.91	-.-	-.-
MT	4.38	3.88	3.59	3.38	4.04	3.72
IL	2.80	2.09	1.76	2.41	2.34	1.90
AP	0.76	0.52	0.37	0.20	0.29	0.35
CI	33.74	43.07	42.93	41.26	42.52	23.97

TABLE 13

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Fraser Lake Mafic Volcanic Subunits 4e, 4f, 4fa

UNIT	4e	4e	4f	4f	4fa	4fa
SAMPLE	082	103	058	063	008	044
SiO2	52.97	49.39	51.14	55.30	58.40	52.31
Al2O3	14.13	16.60	20.23	16.61	15.92	20.24
Fe2O3	3.06	2.21	2.15	2.32	2.24	2.41
FeO	9.97	9.19	5.83	6.58	5.53	8.29
CaO	10.78	12.32	9.83	8.37	7.38	7.84
MgO	4.06	5.74	6.00	6.35	4.16	3.48
Na2O	2.81	2.63	3.70	3.08	2.37	3.16
K2O	0.27	0.24	0.30	0.30	2.95	0.97
TiO2	1.49	1.39	0.59	0.77	0.69	1.00
P2O5	0.24	0.10	0.09	0.09	0.19	0.12
MnO	0.23	0.18	0.13	0.19	0.18	0.18
Cu	34.0	50.0	110.	12.0	27.0	53.0
Ag	<.5	<.5	.5	<.5	1.0	.5
Au	2.	<2.	8.	<2.	2.	12.
Zn	18.0	11.0	25.0	28.0	130.	95.0
Y	30.	30.	10.	10.	10.	10.
Pb	6.	4.	4.	2.	4.	4.
Zr	60.	70.	20.	30.	50.	30.
As	3.	10.	1.	3.	6.	2.
Sb	.9	.9	1.3	.7	.8	1.0
V	330.	380.	190.	260.	290.	300.
Cr	38.	62.	34.	75.	99.	17.
Mo	5.0	3.0	3.0	2.5	1.5	2.5
Co	6.0	15.0	12.0	8.5	29.0	22.0
Ni	10.0	10.0	17.0	11.0	39.0	<.5
QZ	6.64	-.-	-.-	7.10	10.90	3.13
CO	-.-	-.-	-.-	-.-	-.-	0.02
OR	1.61	1.42	1.78	1.77	17.41	5.73
AB	23.74	22.26	31.34	26.02	20.03	26.78
AN	25.16	32.78	37.68	30.80	24.11	38.10
DI	22.37	22.82	8.52	8.22	9.24	-.-
HY	12.67	10.50	8.88	21.05	13.31	20.58
OL	-.-	4.13	7.35	-.-	-.-	-.-
MT	4.43	3.21	3.11	3.36	3.25	3.50
IL	2.82	2.64	1.12	1.46	1.32	1.90
AP	0.57	0.25	0.22	0.22	0.44	0.28
CI	42.29	43.29	28.99	34.09	27.12	25.97

TABLE 14

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Fraser Lake Mafic Volcanic Subunit 4g

UNIT	4g	4g
SAMPLE	078	091
SiO2	53.77	52.70
Al2O3	14.04	15.19
Fe2O3	3.35	2.87
FeO	11.56	11.37
CaO	6.85	6.46
MgO	4.23	4.55
Na2O	3.79	4.73
K2O	0.17	0.14
TiO2	1.83	1.56
P2O5	0.20	0.20
MnO	0.22	0.24
Cu	80.0	72.0
Ag	<.5	<.5
Au	2.	<2.
Zn	23.0	22.0
Y	50.	40.
Pb	2.	<2.
Zr	120.	110.
As	6.	1.
Sb	.6	.4
V	380.	330.
Cr	31.	34.
Mo	2.0	2.0
Co	15.0	14.0
Ni	4.0	5.0
QZ	6.08	-.-
OR	0.98	0.85
AB	32.05	40.04
AN	20.81	19.77
DI	9.99	9.20
HY	21.37	21.02
OL	-.-	1.53
MT	4.86	4.16
IL	3.47	2.96
AP	0.46	0.47
CI	39.69	38.87

Figure 11: AFM and YTC plots for unit 4 samp
A = $Na_2O + K_2O$, F = $FeO + 0.8998(Fe_2O_3)$, M = MgO,
expressed in weight percent. Y = Y + Zr (ppm),
TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram
divided into tholeiitic (T) and calc-alkaline
fields after Irvine and Barager (1971) and the
diagram has Archean tholeiitic (AT), Archean magne
(AM) and Archean calc-alkaline (AC) basalt tr
delimited after Davies et al. (1979).

○ Fraser Lake aphyric andesite (subunit 4a)

● Fraser Lake aphyric basalt (subunit 4b)

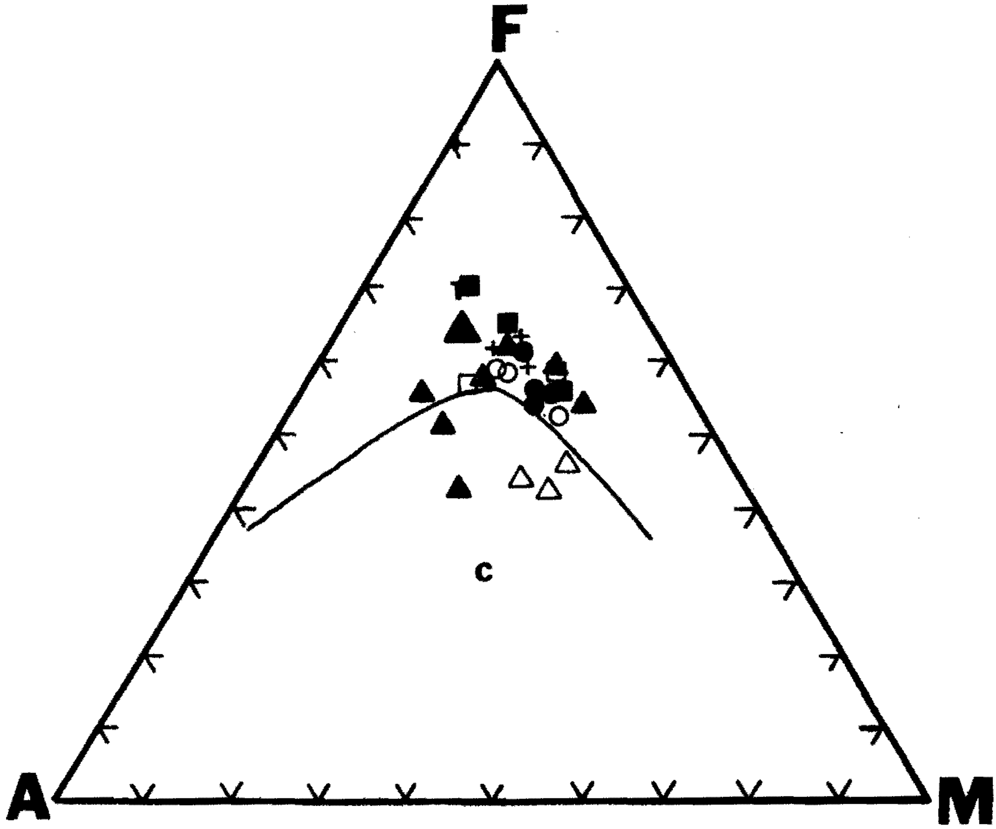
□ Fraser Lake amygdaloidal aphyric andesite (sub
4c)

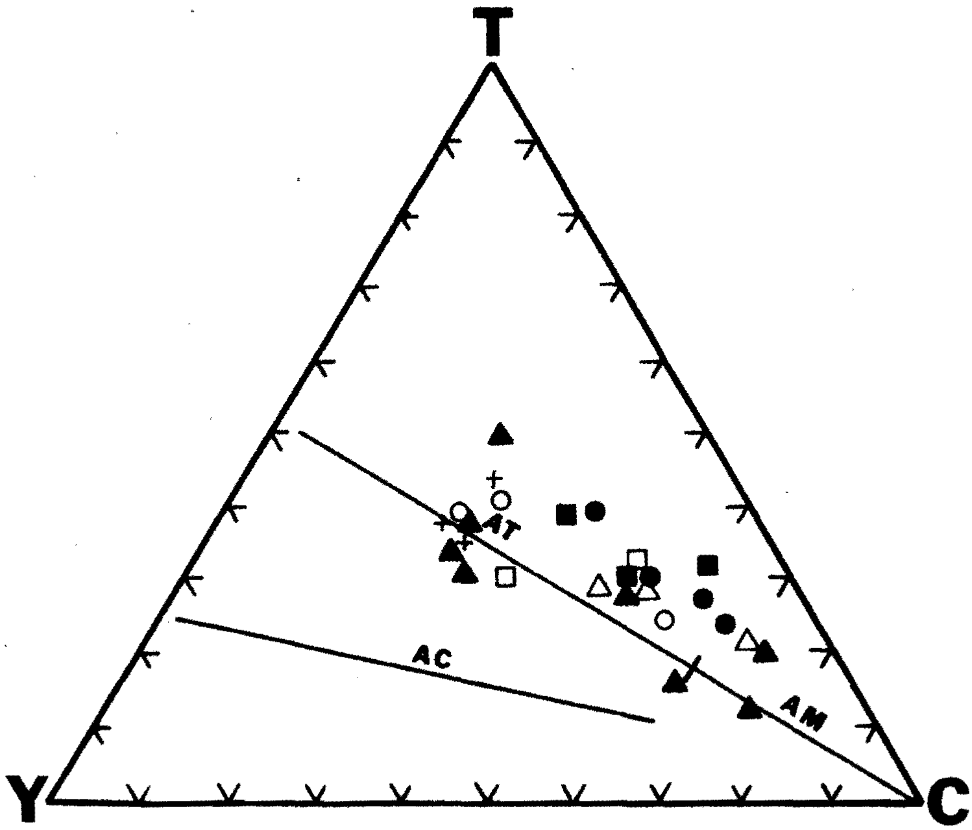
■ Fraser Lake porphyritic basalt (subunit 4e)

△ Fraser Lake mafic tuff (subunit 4f)

▲ Fraser Lake highly altered, chemically mafic
(subunit 4fa)

+ Fraser Lake intermediate tuff (subunit 4g)


F
A
M
c


T
Y
C
AT
AC
AM

1. These rocks are normative quartz andesites and andesites. This fact, combined with field observations that the outcrops appeared very massive and blocky with an almost complete lack of foliation, lead to the conclusion that they are andesitic flows.
2. In thin section, the "relict" opaques are fairly common, again indicating a flow origin. In addition, the rock is distinguished from a greywacke by the "felted", feathery, form of the amphiboles. They are more fibrous and less euhedral than the massive, stubby, highly poikiloblastic amphiboles of the greywackes.
3. There is more modal quartz (mean=4.1) than most basic rocks, and a high amount of amphibole. The amphibole content changes where shearing and consequent chloritization and calcite invasion occurred. In such cases, the amphibole is completely destroyed and higher carbonate and plagioclase contents can be found.
4. The rock is usually hornfelsic but may approach schistose if shearing is prevalent.
5. No phenocrysts are noted.
6. These andesites are always quartz-normative and contain relatively moderate normative color index values (30-40).

7. The rocks exhibit tholeiitic character in both AFM and YTC diagrams.

3.1.11 Fraser Lake Aphyric Basalt (subunit 4b)

Eighteen of twenty-six rocks sampled are basaltic in composition. Of these, three have the characteristics of aphyric basalt flows (subunit 4b).

These characteristics are:

1. The normative classification for these rocks is consistently basalt. This, combined with the general blocky, angular and massive outcrop appearance, infers a flow origin for this unit.
2. "Relict" opaques and fibrous, feathery, felted, non-poikiloblastic amphiboles indicate a flow rather than sedimentary origin.
3. These rocks are generally low in modal non-vein quartz but veining is common. They contain the highest abundance of modal amphibole (mean=73.7) and the least amount of plagioclase of the unit 4 rocks (mean=14.2) (Table 8).
4. The rock is commonly hornfelsic but occasionally has a streaky gneissosity, which may be related to original flow features. No structures, such as pillows, are present.
5. These rocks are generally higher in Au (greater than 3ppb) and lower in Zn (less than 19ppm) (Table 12).

6. Normative quartz is not the rule; some analyses show normative nepheline or olivine (Table 12). Normative olivine occurs in most cases.
7. The rocks exhibit a tholeiitic nature in both AFM and YTC diagrams (Figure 11).

3.1.12 Fraser Lake Aphyric Amygdaloidal Andesite (subunit 4c)

Two outcrops contained an aphyric, amygdaloidal andesite. The characteristics of this rock are exactly the same as subunit 4a except for the presence of amygdales (approximately 20%). Both polycrystalline quartz amygdales and polymineralic quartz, plagioclase, epidote and calcite amygdales, which are sometimes rimmed by chlorite, are present.

3.1.13 Fraser Lake Amygdaloidal Basalt (subunit 4d)

Amygdaloidal basalt does occur within the Fraser Lake mafic volcanic body but is very rarely encountered. Members of this unit are only found around the Brown showing therefore the description of subunit 4d is found in the next chapter.

3.1.14 Fraser Lake Porphyritic Basalt (subunit 4e)

Three of the eighteen outcrops sampled in the Fraser Lake Mafic volcanic body are porphyritic basalt. They are distinguished by:

1. Their normative composition of tholeiitic basalt or basalt.
2. The presence of a high percentage of "relict" opaques (mean=4.3%) as well as feathery, slightly poikiloblastic amphiboles attested to a volcanic origin. Medium-grained (to 1.1mm), highly altered, twinned, anhedral, plagioclase porphyroblasts imparted a porphyritic texture to the rock. In addition, polymineralic and polycrystalline quartz amygdales are present in most of these samples.
3. The rock is most often hornfelsic and usually contains quartz veins.
4. These rocks are either quartz or olivine normative (Table 13).
5. These porphyritic basalts can be distinguished from those of the McVeigh Lake body (unit 3) in that they have a much lower Cr value (less than 180) and have no hornblende pseudomorphs after pyroxene.
6. The AFM and YTC diagrams attest to the primary tholeiitic character of the unit (Figure 11).

3.1.15 Fraser Lake Mafic Tuff (subunit 4f)

Of the twenty-six outcrops sampled, three are tuffaceous and mafic.

They are distinguished by:

1. These rocks are normatively tholeiitic basalts, latite basalts or basalts. The chemistry attests to the mafic nature of the unit and the crenulated "tuffaceous" bedding on outcrop demonstrated its tuffaceous origin.
2. Even though most are sheared, some extensively, the samples do not appear highly altered and still contain rather large amounts of amphibole (mean=31.3%) (Table 9) which occurred with the "shear" minerals muscovite, chlorite and carbonate. Epidosite is very common with epidote having a modal mean of 6.1%.
3. Texturally, the rocks are usually hornfelsic to schistose.
4. Rather high amounts of SiO_2 (between 51 and 55%) are found but part of this results from the volatile-free normalization procedure. High volatile constituents such as H2O and CO2 are common.
5. These examples contained either normative quartz or olivine.

There is little doubt that the rock is altered to some extent. This is best demonstrated by comparing the AFM diagram with the YTC diagram. Points on the AFM diagram, which are more susceptible to change from metasomatic effects, occur within the calc-alkaline field. The more stable element YTC diagram exhibits the samples' true tholeiitic character.

3.1.16 Fraser Lake Altered Mafic Tuff (subunit 4fa)

Eight of twenty-six outcrops fall within this category. This classification applies to some very highly altered rocks which are commonly found within the Pole Lake intermediate volcanic rocks (unit 5). The intense alteration characteristic of these rocks is prominent on outcrop (Figure 12) and implies that the present chemistry may not be indicative of genetic associations but may instead be a metasomatic overprint. Thin-sections do not aid in genetic interpretation.

Distinguishing features of this group are:

1. Normatively, these rocks range from basalt and tholeiitic basalt to quartz latite basalt.
2. Modal quartz is uncharacteristically high (mean=21.2) and plagioclase uncharacteristically low (mean=23.15%) (Table 9). White mica and chlorite are quite abundant (mean=13.3 and 14.0% respectively). Carbonate is also abundant (mean=12.1%). Epidote (mean=13.6%) and epidosite patches are very common. Amphibole is noticably absent (mean=.01%) for such a "mafic" rock.
3. The quartz-rich mineralogy produces a light colored outcrop. The wavy tuffaceous bedding is present and attests to the rock's volcanic origin.
4. Thin-sections contained many structural features such as intense crenulations, augens and an overall phyllonite texture.

Figure 12: Exposure of Fraser Lake altered mafic tuff (subunit 4fa) displaying prominent Z-folding, selective weathering of less resistant layers, and jointing. This exposure is found in the Mirage claim (Plate I).

5. The rock fabric is always schistose and highly contorted.

6. Calcite, quartz veins, intense chloritization, epidotization and sericitization as well as the presence of apatite and tourmaline attest to the mobility of calcium, sodium, potassium and silicon within the rock and, therefore, to its highly altered nature.

7. The previously mentioned mobility resulted in sporadic SiO_2 contents (between 49 and 58%) and unusually high K_2O (up to 3.74%). Zn (greater than 61ppm) and Co (greater than 15ppm) also appear elevated (Table 13).

8. With one exception, all analyses are quartz-normative. The high Al_2O_3 content in some analyses produced normative corundum. The normative color index is erratic but usually less than 27.

9. The AFM diagram shows a highly scattered array, although most points fall within the tholeiitic field. The YTC also shows some scatter but all samples fall along the Archean tholeiitic-magnesian basalt trend (Figure 11).

The high degree of alteration makes an accurate genetic determination impossible but in outcrop these rocks resmeble tuffs. Chemically, they are mafic (though such features as quartz grains floating in a matrix of calcite are not uncommon); hence the name "altered mafic tuff".

3.1.17 Fraser Lake Intermediate Tuff (subunit 4g)

Three of the twenty-six Fraser Lake Mafic Body outcrops sampled are tuffaceous and intermediate in composition.

Distinguishing features of subunit 4g are:

1. Normatively, these rocks are quartz andesite and andesite.
2. Outcrops appeared aphanitic but have the wavy bedding characteristic of tuffaceous rocks.
3. Very little modal quartz (mean=1.1%) and mica and abundant plagioclase (mean=41.9%) and amphibole (mean=51.1%) (Table 10) are present. Because of the fine-grained and untwinned nature of the plagioclase, it is easily confused with quartz. Epidote is completely absent and carbonates only rarely present.
4. The textures exhibited are always gneissic and contained either porphyroblastic amphibole or plagioclase.
5. SiO_2 is consistently found to be between 49 and 51% with unusually high FeO (greater than 9.7%) and TiO_2 (greater than 1.56%) contents (Table 14). The minor elements Y and Zr also appeared high (greater than 20 and greater than 70ppm respectively) with Ni uncharacteristically low (less than 5ppm).
6. Calculations show that both normative quartz and olivine are common (Table 14). Very low normative orthoclase (less than 3.11%) is also noted.

7. A tholeiitic affinity is demonstrated by both the AFM and YTC diagrams (Figure 11).

3.1.18 Intermediate and Felsic Volcanic Rocks of the Pole Lake Area (unit 5)

3.1.18.1 Occurrence

The Pole Lake intermediate and felsic volcanic rocks represent the most extensive predominantly tuffaceous unit within the map area.

Very minor outcrops of unit 5 rocks can be found in the south central portion of the Good claim. They are associated with Fraser Lake mafics (unit 4) and Fraser Lake-Pole Lake clastics (unit 9).

The majority of outcrops are found in the south central Tornado claim and comprise a very prominent ridge running westward to the west end of the K-fir claim. This unit is bounded on the south by a granodiorite sill (unit 17) and on the north by Fraser Lake mafics (unit 4) and Fraser Lake-Pole Lake volcaniclastics (unit 9).

The majority of these rocks are found within the Cartwright Lake shear zone. The shearing took place along roughly the combined unit 5 and 17 (granodiorite sill) boundaries and created a zone of intense schistosity.

3.1.18.2 Field Observations

The Pole Lake intermediate and felsic volcanic rocks have a unique outcrop appearance. As noted earlier, they are prominent ridge-formers with steep angular sides facing north. The weathered surfaces appear medium to light green-grey to tan and the fresh surface is dark grey. The rocks are usually aphanitic with prominent shearing and contortion. Wavy, tuffaceous bedding can be seen within the contorted zones. The micaceous minerals weather out of the outcrop and produce a surface which exhibits very detailed relief. Quartz and calcite veins are quite prevalent, particularly near the K-fir claim. Vein sizes can range from a few millimeters to over 1.5 meters in width. The outcrops are usually moderately magnetic due to secondary magnetite. This gives a linear magnetic high aeromagnetic signature to the outcrop which can be traced into the Cartwright Lake area (Gilbert et al., 1980).

The unit has been divided into two members: an intermediate tuff (subunit 5a) and a dacitic tuff (subunit 5b). Most outcrops are of the 5a type but they increase to SiO_2 and become dacitic to the west.

3.1.18.3 Mineralogy and Chemistry

The typical unit 5 mineralogy (Table 15) involves a high percentage of fine-grained (to .88mm), anhedral plagioclase. The fine-grained, untwinned, mosaic plagioclase groundmass is still common as it is in other volcanic units but a greater percentage of plagioclases are porphyroblastic. These larger grains have myrmekitic areas and are highly altered (saussuritized and/or sericitized). They appear to have overgrowths and Carlsbad, albite, pericline and polysynthetic twinning is common. Some very angular crystal fragments exist where shearing is dominant. Some of these sheared crystals have dislocated twinning which implies that these grains are part of the primary pilotaxitic texture. Later shearing fractured the grains and, still later, sodium-rich metasomatic solutions "healed" the fractured grains resulting in crystals with the dislocated twinning. Limited optical data suggest an anorthite content of An_{28} (oligoclase) but further work with the microprobe (Table 16) shows an An_{38} (andesine) content.

The next most abundant mineral is fine-grained (to .88mm), anhedral quartz. Most occurrences are as a fine-grained groundmass or in veins. Larger grains occur that may be original, sheared, porphyritic crystals. They are generally very angular. The quartz is generally unaltered and undulose, while the plagioclase usually is altered and exhibits normal zoning.

Mica is the next most abundant mineral group with muscovite and chlorite the dominant types; biotite is rare. All are generally fine-grained and found within sheared zones. Some muscovite overprinting is observed where the grains are not directionally aligned, unlike the majority, which exhibit a parallel alignment consistent with the regional shearing and folding. Penninite is the dominant

TABLE 15

Point Counted Modes and Average, Visually Estimated Modes of Pole Lake Intermediate and Felsic Volcanic Rocks (unit 5)

UNIT	5a	5a	5a	5d	5d	5d	5d
SAMPLE	011	031	$\bar{X}$ N=7	019	021	053	$\bar{X}$ N=8
Quartz	1.8	7.4	24.5	5.8	57.4	3.2	37.9
Plagioclase	44.6	52.0	36.1	66.2	8.8	69.4	37.4
White Mica	7.4	1.2	11.0	11.0	24.2	7.2	12.3
Chlorite	27.6	25.2	13.5	pr.	2.6	.2	4.8
Amphibole	-.-	-.-	-.-	-.-	-.-	16.6	2.6
Epidote	-.-	5.0	.7	-.-	-.-	2.0	.8
Carbonate	3.8	7.8	6.3	16.2	5.0	1.4	5.9
Opaque	3.0	1.0	2.9	.6	.8	pr.	1.7
Biotite	2.4	.2	.8	.2	1.2	pr.	1.4
Andularia	-.-	.2	.03	-.-	-.-	-.-	-.-
Tourmaline	-.-	-.-	.01	-.-	-.-	-.-	-.-

$\bar{X}$ - mean
pr. - present

TABLE 16

Typical Chemical Composition of Unit 5 Minerals

SAMPLE	PLAGIOCLASE	OPAQUE	OPAQUE
SiO2	57.1	0.3	0.2
Al2O3	24.2	0.2	0.2
FeO	0.2	45.4	96.1
MgO	0.1	-.-	-.-
CaO	7.1	-.-	0.1
Na2O	6.2	-.-	-.-
K2O	-.-	0.1	-.-
TiO2	-.-	51.8	0.1
P2O5	-.-	-.-	-.-
MnO	-.-	2.9	-.-
ClO	0.1	-.-	-.-
SO3	-.-	0.1	-.-
OXYGEN	5.1	-.-	3.4
TOTAL	100.0	100.8	100.0
SI	9.62	0.01	0.05
AL	4.81	0.01	0.06
FE	0.02	1.91	27.32
MG	0.02	-.-	-.-
CA	1.27	-.-	0.02
NA	2.02	-.-	-.-
K	-.-	0.01	-.-
TI	-.-	1.96	0.03
P	-.-	-.-	-.-
MN	-.-	0.12	-.-
CL	.02	-.-	-.-
S	-.-	0.0	-.-
O	32.0	6.0	32.0
	Ab 61.4 An 38.6		
NAME	Andesine	Ilmenite	Magnetite

chlorite and its occurrence is indicative of shearing. It usually occurs in fine-grained aggregates and may give the thin section an opaque appearance under crossed polars when present in large amounts. Carbonates are found in many outcrops as stringers; both calcite and siderite are common. In one thin section, very minute andularia grains are found within a calcite vein. This is consistent with the accepted occurrence of andularia as a feldspar found in veins and replacement deposits in some rocks of low-grade metamorphism (Kerr, 1977). Minute tourmaline crystals are also present in trace amounts. Except in one thin section, amphiboles are completely absent. Epidote is common in very minor amounts (mean=.7%). Opaques are not abundant; the dominant types are subhedral ilmenite and the previously mentioned euhedral secondary magnetite.

Many thin sections exhibit enough shearing so that all volcanic fabrics have been obliterated. High amounts of chlorite, muscovite, and biotite occur within these areas parallel to the veining directions. Many of the opaques are also aligned in this direction. By following the opaque-rich zones in plane-polarized light, definite micro-faulting can be observed which is hard to discern in cross-polarized light.

Generally, the highly sheared examples contain 85% sheared fragments of which 80% are gneissic and 20% mostly polycrystalline quartz. The gneissosity of the fragments may belie the original tuffaceous character of the rock. The polycrystalline quartz areas may be the remnants of amygdales or veins and some of the polymineralic quartz, plagioclase and calcite fragments may also have this origin.

Finally, a few discernible lapilli fragments exist (Figure 13) but not in large enough quantities to result in a lithic tuff name for the samples.

The dominant mineralogy of plagioclase (andesine) + quartz + chlorite (penninite) + mica + carbonate + opaques (magnetite and ilmenite) + biotite ± epidote ± andularia represents the greenschist facies of Williams, Turner and Gilbert (1954). The unit is quartz-normative.

The Pole Lake volcanic rocks are divided into two members; an intermediate tuff (subunit 5a) and a dacitic tuff (subunit 5b). Gilbert et al. (1980) has assigned this unit a calc-alkaline affinity but the analyses for this study show a wide scatter of points on the AFM and YTC diagrams (Figure 14). That this unit has been affected by metasomatic activity is not in doubt, given the metasomatic history of the rest of the area and the amount of shearing (i.e. potential ion migration pathways) present within this unit. This would account for the scattering of points on the AFM diagram. It does appear that most of the intermediate tuff samples (subunit 5a) show a tholeiitic affinity on both diagrams and that the majority of the dacitic tuff members (subunit 5b) exhibit a calc-alkaline affinity. This

Figure 13: Photomicrograph of altered lap
fragments from the Pole Lake intermediate tuff (sub
5a). The groundmass is highly chloritized.
calcite vein running through the center of the area
twinned plagioclase crystal in the lower left. Cr
polars, 82x.

unit may therefore represent two conformable units of different or changing chemical affinity.

3.1.19 Pole Lake Intermediate Tuff (subunit 5a)

Samples were collected from eighteen outcrops of Pole Lake intermediate and felsic volcanic rocks. Of these eighteen, eight are intermediate in composition (subunit 5a).

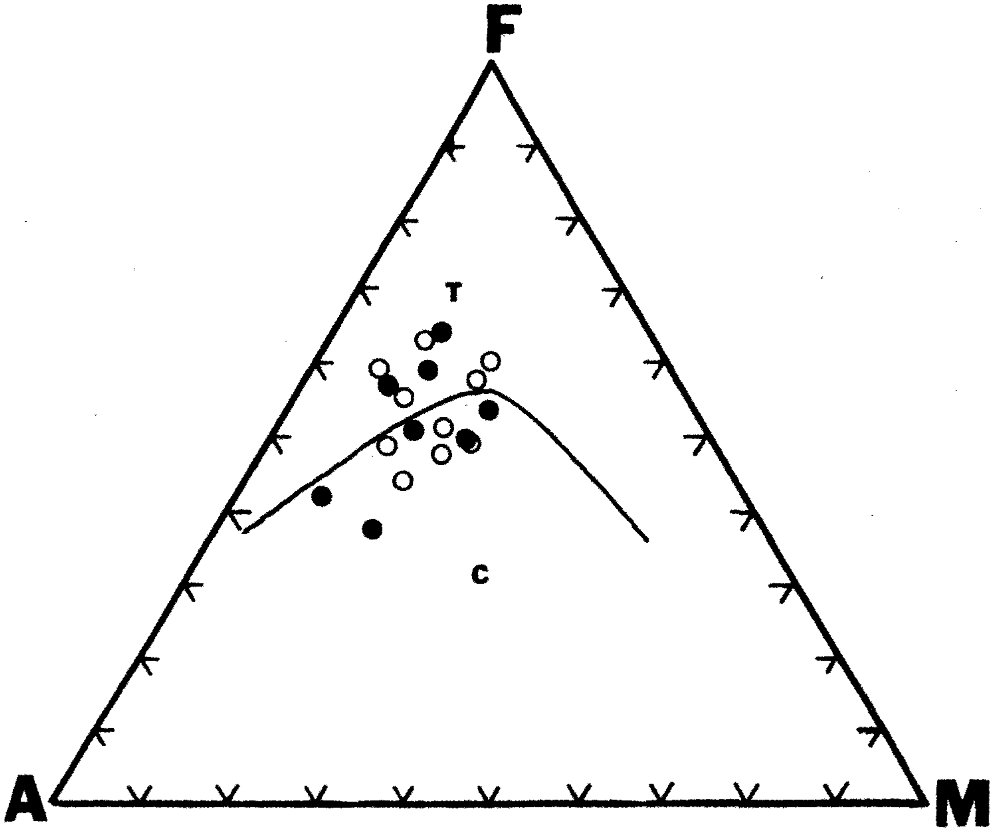
They are distinguished from other unit 5 rocks by the following:

1. These samples are normative quartz andesites and quartz latite andesites.
2. There appears to be less modal quartz (mean=24.5%) while typical alteration minerals such as chlorite, andularia and tourmaline are found more often. Opaques (mainly magnetite) are also more abundant.
3. The rock fabric is always sheared and schistose, very commonly with cataclastic areas and flaser structure.
4. There are lower SiO_2 contents (generally less than 60%) higher Au (usually greater than 3ppb) and lower Zr (less than 80ppm) (Table 17).
5. Normative quartz and sometimes corundum are present.
6. A tholeiitic affinity is evident from the AFM and YTC diagrams (Figure 14).

Figure 14: AFM and YTC plots for unit 5 samples. A = $Na_2O + K_2O$, F = $FeO + 0.8998(Fe_2O_3)$, M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1979).

○ Pole Lake intermediate tuff (subunit 5a)

● Pole Lake dacitic tuff (subunit 5b)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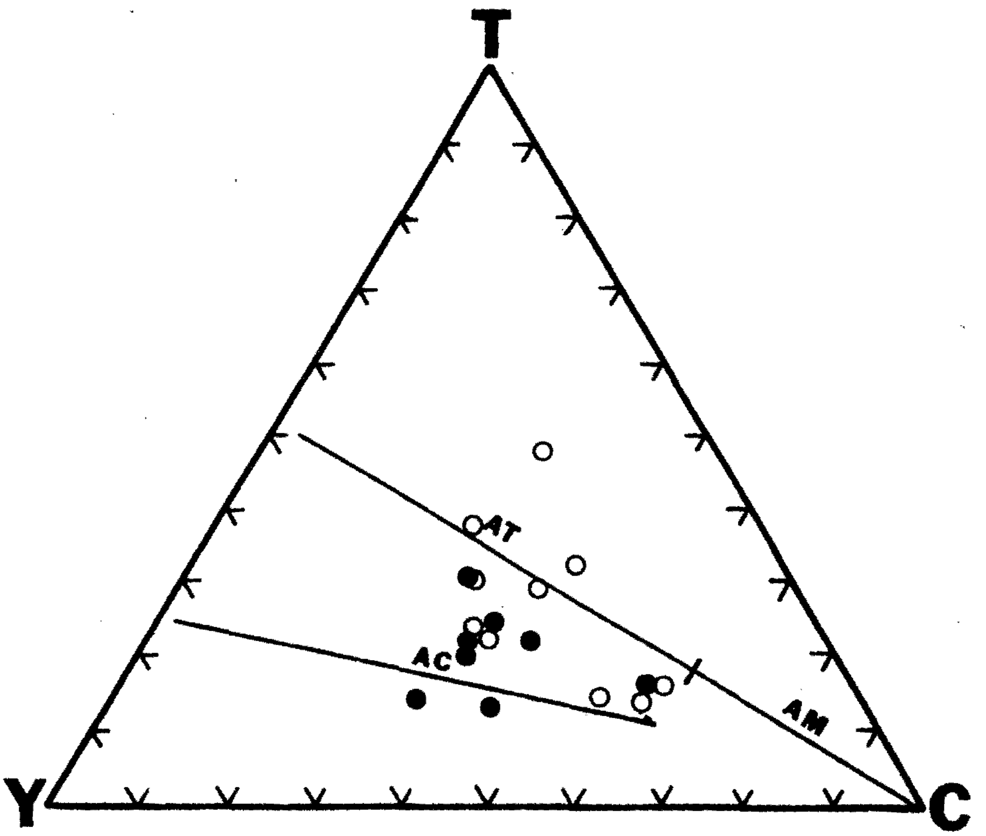
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3.1.20 Pole Lake Area Dacitic Tuff (subunit 5b)

Ten of eighteen outcrops sampled proved to be the dacitic tuff member 5b.

Distinguishing features are as follows:

1. The samples are all normative dacite.
2. More modal quartz is present (mean=37.9%) and less chlorite (mean=4.8%) and opaques (mean=1.2%) (Table 15). Only one sample is found to contain amphiboles. This sample is located at the farthest westward extent of subunit 5b and is the only example of albite-epidote amphibolite facies for this member. Alteration minerals are less abundant than in subunit 5a but shearing and alteration is nevertheless common.
3. Schistose and gneissic fabrics are well developed.
4. The rocks generally contain more SiO_2 (greater than 59%) and have elevated K_2O contents.
5. Normative quartz exceeded 15% and normative corundum is quite common (Table 17).
6. The samples are predominantly of calc-alkaline affinity (Figure 14).

3.1.21 Fraser Lake Dacitic Tuff (subunit 6a)

3.1.21.1 Occurrence

Only one outcrop is found that contains the Fraser Lake dacitic tuff. Located in the Central portion of the

TABLE 17

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Pole Lake Intermediate and Felsic Volcanic Rocks (unit 5)

UNIT	5a	5a	5a	5b	5b	5b
SAMPLE	011	017	126	005	043	111A
SiO2	54.17	70.75	57.15	67.58	63.09	58.72
Al2O3	15.64	13.14	20.04	14.28	15.54	17.23
Fe2O3	2.31	1.91	2.24	2.06	2.22	2.30
FeO	9.38	3.78	5.69	5.50	6.81	7.06
CaO	9.87	4.08	4.29	4.02	5.29	5.99
MgO	3.17	1.45	2.99	1.06	1.85	3.85
Na2O	3.51	3.64	1.51	3.36	3.31	2.46
K2O	0.70	0.63	4.58	1.33	0.99	1.47
TiO2	0.92	0.44	0.61	0.57	0.63	0.70
P2O5	0.07	0.08	0.08	0.10	0.08	0.07
MnO	0.27	0.09	0.14	0.15	0.18	0.15
Cu	190.	15.0	25.0	46.0	200.	12.0
Ag	<.5	<.5	.5	<.5	<.5	.5
Au	9.	<2.	5.	3.	<2.	<2.
Zn	140.	62.0	100.	95.0	98.0	58.0
Y	20.	30.	20.	20.	20.	20.
Pb	8.	°2.	6.	<2.	4.	6.
Zr	10.	70.	70.	90.	90.	80.
As	1.	3.	2.	<1.	6.	3.
Sb	1.2	.9	.9	1.1	2.5	.4
V	300.	46.	230.	13.	110.	200
Cr	21.	41.	31.	31.	31.	44.
Mo	3.0	3.0	3.0	2.5	3.0	2.0
Co	21.0	4.5	19.0	4.5	19.0	17.0
Ni	.5	<.5	5.0	<.5	<.5	<.5
QZ	3.98	34.75	11.72	29.47	21.89	15.80
CO	-.-	-.-	4.08	0.22	-.-	0.89
OR	4.16	3.73	28.70	7.88	5.87	8.68
AB	29.67	30.78	13.55	28.46	27.99	20.79
AN	24.82	17.66	22.01	19.31	24.61	29.22
DI	20.00	1.69	-.-	-.-	0.94	19.78
HY	12.10	7.58	15.26	10.36	14.08	-.-
MT	3.35	2.77	3.24	2.99	3.22	3.33
IL	1.74	0.84	1.23	1.08	1.20	1.33
AP	0.16	0.20	0.20	0.23	0.20	0.18
CI	37.19	12.89	19.74	14.44	19.44	24.44

Rabbit's claim, it is interbedded with the Fraser Lake mafic volcanic body (unit 4). This occurrence is consistent with the findings of Gilbert et al. (1980). The outcrop occurs as part of a topographical high, resistant ridge. The rock is aphanitic but some autoclastic breccia clasts measuring up to 7.6 x 40 centimeters are present. The outcrop weathered dark grey to brown. Minor quartz and calcite stringers and traces of sulfides are apparent.

3.1.21.2 Mineralogy and Chemistry

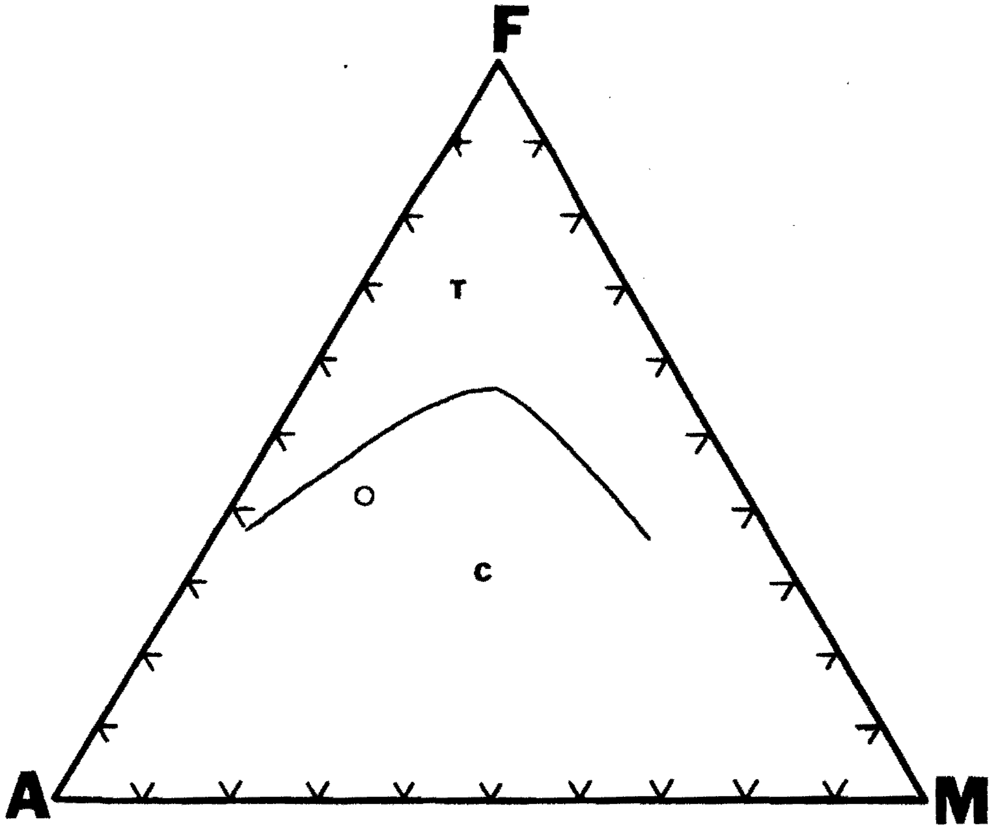
The point-counted modes of subunit 6a show 60.8% fine-grained, anhedral, untwinned plagioclase making up the groundmass mosaic. Interstitial, fine-grained muscovite (26.4%) is present, as is fine-grained, anhedral, mosaic quartz (12.6%). Calcite is accompanied by fine-grained biotite and opaques in trace amounts. The rock has a granoblastic texture with folding and shearing evident.

The unit is of greenschist facies mineral assemblage. The sample contained high SiO_2 (64.76%) as well as high K_2O (2.21%).

The rock is a normative dacite with quartz and corundum present (analysis 100, appendix B). A calc-alkaline affinity is evident from the AFM and YTC diagrams (Figure 15).

Figure 15: AFM and YTC plots for unit 6 samples. A = Na_2O + K_2O, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1979).

O Fraser Lake dacitic tuff (subunit 6a)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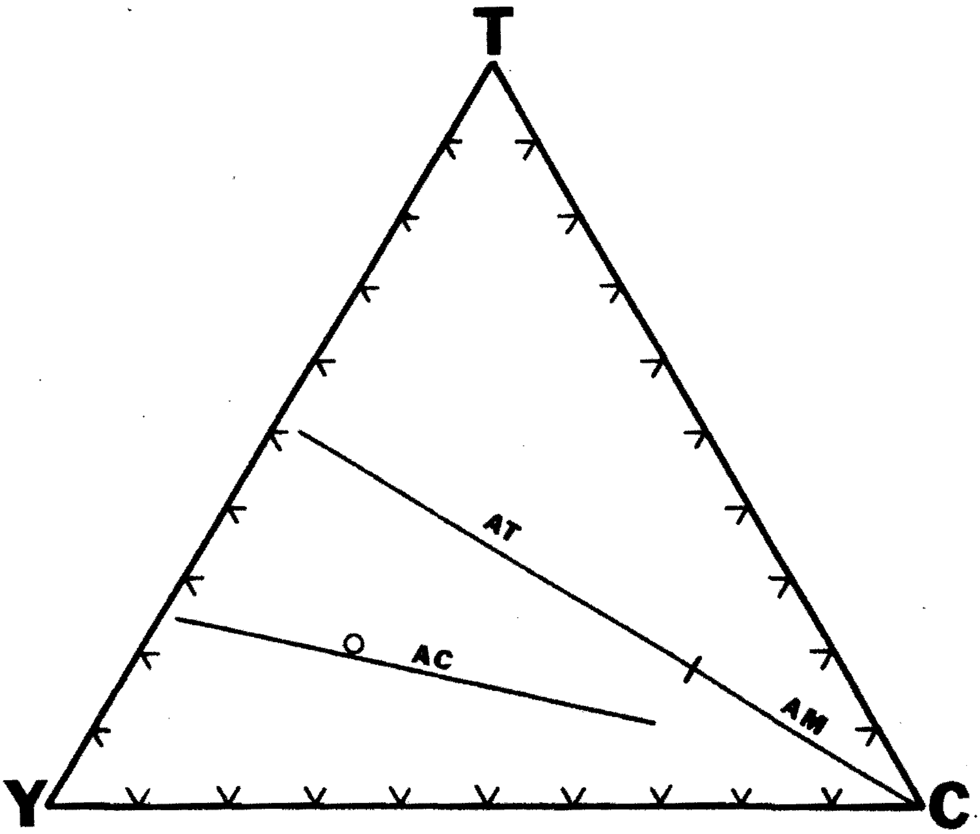
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3.2 VOLCANICLASTIC SEDIMENTARY ROCKS

3.2.1 Fraser Lake-Eldon Lake Sedimentary Rocks (unit 9)

3.2.1.1 Occurrence

The volcaniclastic sedimentary rocks occurring within the map area appear to fit within the Eldon Lake section (unit 9) distal facies divisions C and D of Gilbert et al. (1980).

The volcaniclastics occur centrally in the map area. Within the Rabbit's claim, the Eldon Lake volcaniclastics' northern contact is with the McVeigh porphyritic basalt (subunit 3b), the Fraser Lake porphyritic basalt (subunit 4e) and the Cockeram Lake andesite platform (subunit 2a) from west to east. The southern contact is with the sheared granodiorite (unit 17) which represents the furthest westward extent of the Cartwright Lake shear zone. There are additional occurrences of volcaniclastics within the McVeigh Lake and Fraser Lake bodies.

In the Good claim, the Eldon Lake volcaniclastics have a southern contact with the Fraser Lake mafic volcanic rocks and appear to "wrap" around the westward extent of these volcanic rocks so that they are in contact with the granodiorite sill (unit 17).

Throughout the map area, the contact of the sedimentary sequence (unit 9) is with the Cockeram Lake volcanic rocks (unit 2). The southern contact is with the Fraser Lake mafics (unit 4) in the west and with the intermediate volcanic rocks of the Pole Lake area (unit 5) in the east. Minor interbeds of Eldon Lake volcaniclastics can be found within the Pole Lake rocks.

Structurally, this unit occupies the southern limb of the McVeigh Lake anticline. Thickening by folding may have occurred, particularly where this unit is in contact with the Cartwright Lake shear zone. The sequence appears to be structurally less competent than the surrounding volcanic rocks and therefore contains many local shear zones.

3.2.1.2 Field Observations

The Fraser Lake-Eldon Lake volcaniclastics appear dark-grey when hornblende-bearing, medium green-grey when biotite-bearing and white if predominantly quartz-bearing. Outcrops are usually resistant ridge-formers. Bedding is prominent and can range from a few millimeters to a meter or more in thickness. Some areas have a very fine-grained character and appear silty or cherty. Foliation parallel to the bedding is common. Very rare cross-bedding and normal graded bedding suggests a turbidite type origin for much of the unit. Other very fine-grained, bedded sections indicate quiet-water deposition, which is consistent with the interpretation of Gilbert et al. (1980).

Fine-grained hornblende and fine-grained quartz crystals are common. Quartz and calcite stringers are usually parallel to the bedding direction. Minor sulfides are also present.

The unit has been divided into two members: a hornblende-bearing, usually feldspar-bearing greywacke (subunit 9a) and a siltstone (subunit 9b). Contacts between the hornblende-bearing greywackes (subunit 9a) and siltstones (subunit 9b) range from gradational to very sharp. The name greywacke is according to the use of Gilbert et al. (1980). Feldspar can be present in substantial amounts but it is not always present or easily identified in its fine-grained, anhedral, untwinned form. The term greywacke, as used here, will imply a mafic, volcaniclastic, well-bedded meta-sedimentary rock and is not an indication of the present modal content of quartz, feldspar and clay. Metamorphic changes, primarily amphibole blastesis generally make primary compositional characteristics impossible to determine.

3.2.1.3 Mineralogy and Chemistry

One of the most distinctive and common major minerals of the Fraser Lake-Eldon Lake volcaniclastics is amphibole. The amphiboles range from a blue-green pleochroic variety, representing a lower grade metamorphic facies (high greenschist to low albite-epidote amphibolite) in the east to a green and brown variety in the west representing a higher grade facies (albite-epidote amphibolite facies). The amphiboles are usually medium-grained (to 1.1mm), porphyroblastic, anhedral to subhedral, prismatic and very poikiloblastic with quartz, plagioclase and opaques. So many inclusions are present that the amphiboles usually have a pronounced sieve texture (Figure 16). Twinning is common. The amphiboles probably represent a recrystallization of the very fine-grained, mafic portion of the rock's matrix. The amphibole content sometimes varies between beds. Microprobe analysis shows that the dominant green pleochroic amphibole is common hornblende (Table 18).

Quartz is the next most common constituent of the samples. It is commonly fine-grained (to .1mm) and commonly occurs as a mosaic of recrystallized grains forming the groundmass. Some quartz veining is also present. Rarely, original grains are observed which have overgrowths, undulose extinction and appear to have been elongated parallel to the regional foliation direction. Layers of differing grain size are probably related to the original size heterogeneities of different beds. Discrimination between quartz and plagioclase is very difficult; optic sign determination is the best test if the grains are large enough. The resulting quartz percentage should thus be taken as a maximum and the feldspar mode as a minimum value.

Plagioclase is the next most abundant mineral species and usually occurs as fine-grained, anhedral, untwinned grains intermixed with a mosaic of quartz grains in the groundmass. Fine-grained, anhedral, slightly sericitized, albite-twinned, normally zoned plagioclase is present, and is determined optically to be andesine (An_{30}).

Figure 16: Photomicrograph of hornblende-bearing greywacke from sample 150. Note the highly poikiloblastic, porphyroblastic amphiboles in a groundmass of quartz (clear), mica (fiberous) and opaques. Crossed polars, 71x.

TABLE 18

Typical Chemical Composition of Unit 9 Minerals

SAMPLE	AMPHIBOLE	EPIDOTE	CHLORITE	OPAQUE	OPAQUE
SiO2	49.6	37.3	26.4	0.2	-.-
Al2O3	16.8	23.0	19.2	0.1	0.3
FeO	11.0	13.0	21.8	43.9	96.0
MgO	15.4	0.2	15.8	-.-	-.-
CaO	10.2	24.4	0.1	0.2	0.2
Na2O	3.3	0.3	0.3	-.-	-.-
K2O	0.3	-.-	0.1	-.-	0.1
TiO2	0.3	0.4	0.1	52.6	-.-
P2O5	-.-	-.-	-.-	-.-	-.-
MnO	-.-	0.2	0.3	6.5	-.-
ClO	-.-	-.-	0.1	-.-	0.1
SO3	-.-	0.1	-.-	-.-	-.-
OXYGEN	3.3	1.1	15.5	-.-	3.3
TOTAL	100.0	100.0	100.0	103.5	100.0
SI	6.87	3.07	5.05	0.01	-.-
AL	2.74	2.23	4.39	0.01	0.12
FE	1.27	0.89	3.49	1.80	27.48
MG	1.11	0.02	4.50	-.-	-.-
CA	1.51	2.15	0.02	0.01	0.08
NA	0.89	0.04	0.11	-.-	-.-
K	0.05	-.-	0.02	-.-	0.04
TI	0.03	0.02	0.02	1.94	-.-
P	-.-	-.-	-.-	-.-	-.-
MN	-.-	0.02	0.05	0.27	-.-
CL	-.-	-.-	0.02	-.-	0.07
S	-.-	0.01	-.-	-.-	-.-
O	24.0	13.0	36.0	6.0	32.0
AR=	46.5				
NAME	Hornblende	Epidote	Ripidolite	Ilmenite	Magnetite

AR - amphibole ratio

ome plagioclases are porphyritic and represent original rains.

Mica is usually present, implying that the original ocks were pelitic. The most common mica is fine-grained to .19mm), subhedral muscovite which imparts a schistosity o the rock. The muscovite is found concentrated in the mphibole-rich areas of the greywackes and quartz-rich areas f the siltstones. Two generations of muscovite are bserved in many thin sections, with a coarser-grained mus- ovite cutting a finer-grained one. The majority of muscov- te occurs in sheared zones. Chlorite is another mica com- only present in the samples. It is commonly fine-grained to .1mm) and secondary. Two varieties are common: one is green-pleochroic prochlorite which is associated with mphibole alteration, the other is the common Berlin blue enninite (ripidolite in microprobe analysis-Table 18) and s usually related to sheared zones within the rocks.

Opaques are present in minor amounts and are usually ither ilmenite or magnetite. They occur as anhedral blebs nagnetite) or euhedral blades (ilmenite). They are usually ound in the more mafic, amphibole-rich areas and maintain a near trend which may represent relict bedding.

Calcite stringers, fine-grained, granular epidote, nor biotite and very rare potassium feldspar are also esent, as are rare occurrences of garnet within the silt- one members (subunit 9b).

The unit 9 mineralogy of quartz + green hornblende + plagioclase (andesine) + muscovite + chlorite + calcite + epidote + opaques (ilmenite and magnetite) ± orthoclase represents the albite-epidote amphibolite facies in the west. Further east, the high greenschist, lower albite-epidote amphibolite facies is represented by blue-green amphibole (tschermakitic hornblende) + plagioclase (andesine) + muscovite + chlorite + carbonate + opaque ± epidote. The unit has retained a remarkably mafic character (Table 19) and is not always quartz-normative.

3.2.2 Fraser Lake-Eldon Lake Hornblende-bearing Greywacke (subunit 9a)

Of the thirty-seven volcaniclastic outcrops encountered, twenty-six are hornblende-bearing greywacke (subunit 9a).

The characteristics are as follows:

1. A wide range of basaltic and andesitic normative names are derived which demonstrates the wide chemical differences and the mafic to intermediate nature of the unit.
2. The presence of bedding with rare crossbedding and normal graded bedding on outcrop strongly supports the concept that these are reworked volcanic sediments.
3. The presence of highly poikiloblastic hornblende in amounts greater than 10% is very definitive. In

TABLE 19

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Fraser Lake-Eldon Lake Volcaniclastic Rocks (unit 9)

UNIT	9a	9a	9a	9b	9b	9b
SAMPLE	057	083	097	029	095	143
SiO2	52.26	64.82	51.45	63.77	53.92	47.52
Al2O3	15.24	14.18	16.56	14.88	17.53	20.05
Fe2O3	2.62	2.19	2.25	0.70	2.35	2.53
FeO	9.01	6.78	8.37	8.11	7.63	8.51
CaO	9.78	5.04	8.68	3.82	7.43	9.82
MgO	6.02	1.72	7.15	3.97	4.67	4.57
Na2O	3.19	4.03	2.39	1.40	2.40	3.24
K2O	0.39	0.15	2.10	1.93	2.82	2.64
TiO2	1.05	0.77	0.69	0.84	0.80	0.89
P2O5	0.22	0.17	0.17	0.14	0.28	0.07
MnO	0.21	0.15	0.20	0.10	0.16	0.17
Cu	48.0	47.0	99.0	71.0	190.	3.0
Ag	.5	<.5	.5	.5	.5	<.5
Au	3.	<2.	2.	9.	<2.	<2.
Zn	34.0	54.0	60.0	100.	100.	61.0
Y	20.	50.	0.	30.	30.	0
Pb	6.	4.	2.	4.	<2.	8.
Zr	70.	160.	10.	150.	50.	0.
As	4.	3.	5.	2.	4.	4.
Sb	.9	1.0	2.3	.3	.6	.5
V	370.	48.	240.	170.	240.	300.
Cr	48.	38.	51.	38.	62.	99.
Mo	4.5	2.0	5.0	1.0	<.5	7.0
Co	8.5	6.0	32.0	22.0	27.0	28.0
Ni	11.0	<.5	23.0	1.0	17.0	6.0
QZ	1.47	24.34	-.-	27.63	3.37	-.-
CO	-.-	-.-	-.-	3.43	-.-	-.-
OR	2.28	0.91	12.44	11.87	16.70	15.59
AB	27.03	34.07	20.18	12.32	20.33	12.61
NE	-.-	-.-	-.-	-.-	-.-	8.01
AN	26.11	20.15	28.27	18.76	28.69	32.40
DI	17.28	3.17	11.20	-.-	5.26	13.18
HY	19.51	12.32	17.27	22.98	20.08	-.-
OL	-.-	-.-	5.70	-.-	-.-	12.7
MT	3.80	3.17	3.26	1.01	3.41	3.67
IL	2.00	1.46	1.31	1.66	1.53	1.70
AP	0.52	0.41	0.39	0.34	0.66	0.15
CI	42.60	20.12	38.73	25.65	30.27	31.25

addition, higher amounts of plagioclase (mean=9.5%) are present than in member 9b (Table 20).

This unit is highly diverse both chemically and modally but the presence of bedding on outcrop sets these examples apart from the non-reworked volcanic rocks.

Figure 17 demonstrates that subunit 9a is predominantly tholeiitic when the SiO_2 content is less than 54% and more calc-alkaline when SiO_2 contents are greater than 54%. This may imply more than one source area for these greywackes, some from tholeiitic areas and others (fewer in number) from calc-alkaline sources. The abundance of very low SiO_2 contents also appears to indicate a local source area with little reworking of the sediments, as a longer transport history would probably result in higher SiO_2 contents by the process of weathering or winnowing out of the mafics. The predominant tholeiitic character of these sedimentary rocks also implies that most of the subaerial volcanic rocks were tholeiitic during the time of volcaniclastic deposition.

3.2.3 Fraser Lake-Eldon Lake Siltstone (subunit 9b)

Eleven of the thirty-seven outcrops encountered within the volcaniclastic section were of this type. Discriminating factors are:

1. Very complex chemistry resulting in highly variable normative names ranging from basalt to dacite.

TABLE 20

Point Counted Modes and Average, Visually Estimated Modes of Fraser Lake-Eldon Lake Volcaniclastic Rocks (unit 9)

UNIT	9a	9a	9a	9b	9b	9b
SAMPLE	057	119	Mean N=24	131	134	Mean N=10
Quartz	27.4	49.8	47.0	17.6	67.0	56.8
Plag	1.4	5.8	9.5	-.-	1.6	4.0
White Mica	4.4	1.6	7.7	73.6	1.6	19.0
Chlorite	2.6	4.0	3.5	-.-	1.6	3.6
Amph	59.2	35.4	41.65	-.-	19.6	4.0
Epidote	.6	.4	2.0	7.0	.4	4.5
Carbonate	.2	.8	2.7	-.-	6.2	3.7
Opaque	4.2	2.2	1.9	.2	2.0	1.1
K-spar	-.-	pr.	pr.	-.-	-.-	-.-
Biotite	-.-	-.-	-.-	1.4	pr.	2.2
Garnet	-.-	-.-	-.-	.2	-.-	pr.

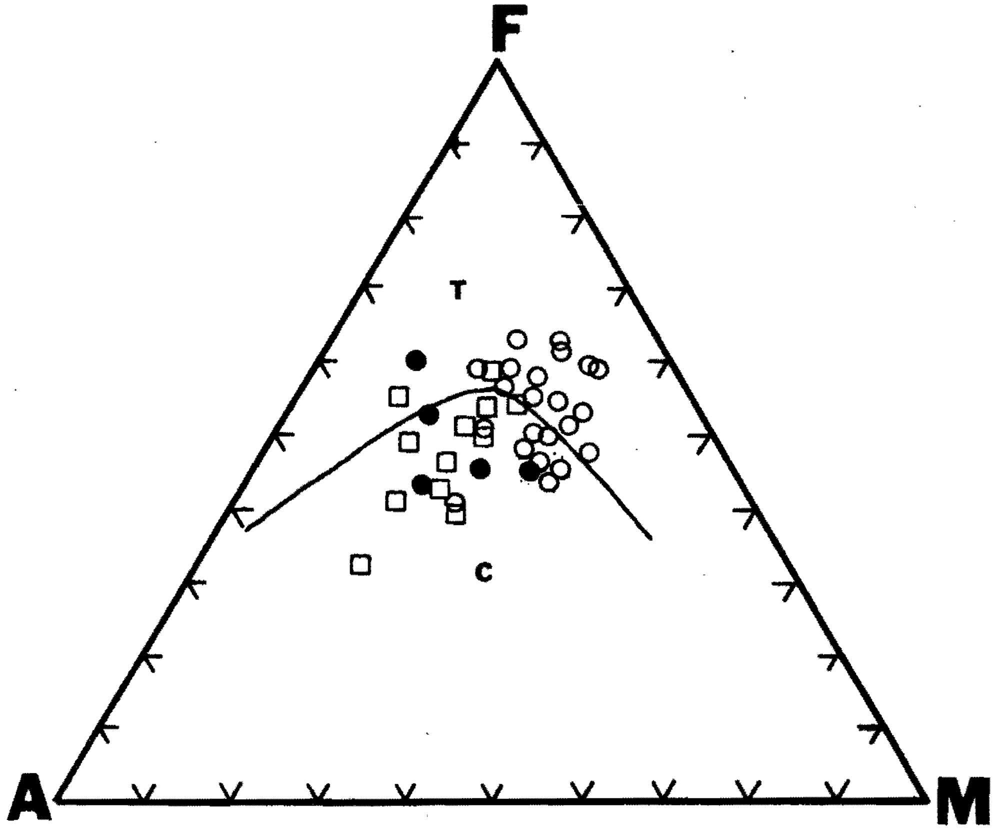
pr. - present

Figure 17: AFM and YTC plots for unit 9 samples. A = $Na_2O + K_2O$, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1979).

○ Fraser Lake-Eldon Lake hornblende-bearing greywacke (subunit 9a) SiO_2 less than 54%.

● Fraser Lake-Eldon Lake hornblende-bearing greywacke (subunit 9a) SiO_2 greater than 54%

□ Fraser Lake-Eldon Lake mica-bearing siltstone (subunit 9b)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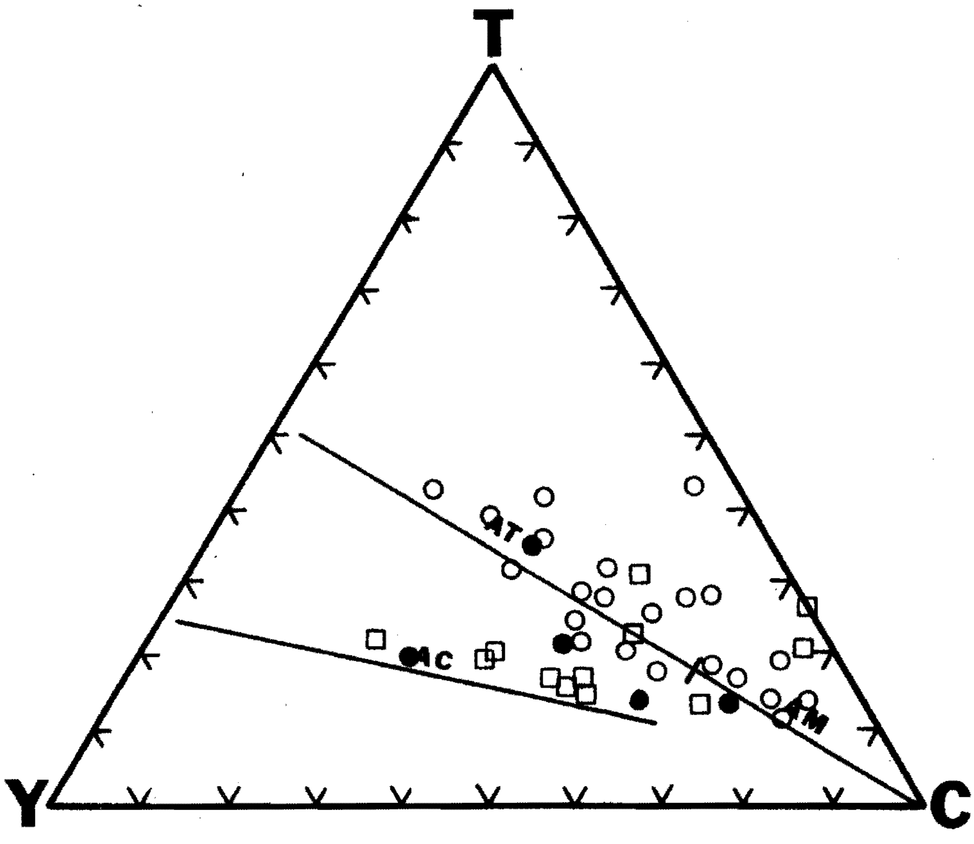
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2. Bedding is present and is defined by mica or amphibole content or by similarly sized layers of quartz.
3. The unit appears much lighter in color and more quartz-rich than most volcanic rocks.
4. Modal quartz content is very high (mean=56.8%) as is muscovite (mean=19.0%); plagioclase (mean=4.0%) and amphibole (mean=4.0%) are very low (Table 20). The presence of less than 10% amphibole represented the dividing line in this study between greywacke and siltstone members.
5. A predominant calc-alkaline character is evident (Figure 17).

3 INTRUSIVES

.1 Subvolcanic Intrusives (unit 1)

Two subvolcanic intrusives have been found within the area. Both contain interesting and potentially impor- t mineralization.

.2 Subvolcanic Intrusive, Rabbit's Claim

This occurrence occupies only one outcrop which is nd along the western border of the Rabbit's claim approx- tely 213 meters north of Dutton Lake. It occurs within Fraser Lake porphyritic basalt (subunit 4e) and near the thern boundary of the Fraser Lake intermediate tuff bunit 4g).

The exposure produces a medium to dark grey, resistant, bench-like outcrop. Upon inspection, it appears to be composed almost entirely (nearly 100%) of medium-grained (to 1mm), subparallel amphibole. Calcite and quartz stringers up to 2.5 cm across also occur. The rock exhibits very strong gneissosity that is parallel to the regional foliation.

Thin-section analysis reveals 45.4% medium-grained (to 2.2mm), subhedral, fibrous, green, non-pleochroic amphibole that has a fine-grained sericitic alteration around its edges and along cleavage fracture. Microprobe analysis (Table 21) shows this amphibole to have an actinolite composition. One of the most obvious minerals in the thin section is a coarse-grained (to 4mm), subhedral, elongate, blue pleochroic, poikiloblastic tourmaline. It has a hexagonal cross-section and appears to have a darker green (chlorite?) alteration around its edges. Microprobe analysis and X-ray diffraction both confirm that the tourmaline is schorlite. All quartz present within the thin section (Table 22) is found exclusively as poikiloblasts within this tourmaline.

Chemically (Table 23), the sample is mafic (SiO_2=49.8%) and, in fact, the sample is a normative gabbro. Both CaO and MgO are high (both=10.7%). Very high Au levels are present (80ppb) and also very large amounts of Cr (212 ppm). The sample is olivine-normative and has a moderate normative color index (43.4) (Table 23).

TABLE 21

Typical Chemical Composition of Unit 1 Minerals

SAMPLE	QUARTZ	AMPHIBOLE	TOURMALINE
SiO2	97.8	52.8	35.0
Al2O3	0.5	3.3	31.4
FeO	-.-	12.7	4.2
MgO	-.-	12.7	7.2
CaO	-.-	12.5	1.5
Na2O	0.2	0.6	1.0
K2O	-.-	-.-	-.-
TiO2	-.-	-.-	0.1
P2O5	-.-	-.-	-.-
MnO	0.2	0.4	-.-
ClO	-.-	-.-	-.-
SO3	-.-	-.-	-.-
OXYGEN	1.4	5.0	18.6
TOTAL	100.0	100.0	100.0
SI	0.97	7.27	5.08
AL	0.01	0.53	5.38
FE	-.-	1.46	0.51
MG	-.-	2.61	1.56
CA	-.-	1.85	0.23
NA	0.00	0.17	0.55
K	-.-	-.-	-.-
TI	-.-	-.-	0.01
P	-.-	-.-	-.-
MN	0.00	0.05	-.-
CL	-.-	-.-	-.-
S	-.-	-.-	-.-
O	2.0	24.0	31.0
AR=		63.4	
NAME	Quartz	Actinolite	Schorl

AR - amphibole ratio

TABLE 22

Point Counted Modes of Subvolcanic Rocks (unit 1)

UNIT	1	1
SAMPLE	089	110
Quartz	6.0	.2
Plagiocase	-.-	pr.
White Mica	-.-	pr.
Chlorite	pr.	12.
Amphibole	45.4	82.6
Epidote	-.-	.2
Carbonate	-.-	3.8
Opaques	-.-	1.2
Tourmaline	48.6	-.-

pr. - present

TABLE 23

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Subvolcanic Intrusive Rocks (unit 1)

UNIT	1	1
SAMPLE	089	110
SiO2	49.78	49.16
Al2O3	17.18	10.87
Fe2O3	1.70	1.97
FeO	7.00	8.86
CaO	10.73	10.36
MgO	10.73	16.46
Na2O	2.00	0.88
K2O	0.58	0.34
TiO2	0.14	0.65
P2O5	0.01	0.19
MnO	0.17	0.26
Cr	2.0	18.0
Ag	<.5	<.5
Au	80.	72.
Zn	11.0	34.0
Y	10.	0.
Pb	4.	4.
Zr	0.	20.
As	29.	350.
Sb	1.2	1.1
V	180.	240
Cr	212.	790.
Mo	3.0	2.0
Co	21.0	50.0
Ni	31.0	260.
OR	3.45	2.00
AB	16.92	7.41
AN	36.19	24.72
DI	13.67	20.39
HY	15.01	29.86
OL	12.02	11.08
MT	2.46	2.86
IL	0.26	1.24
AP	0.02	0.45
CI	43.3	65.44

This sample probably does not reflect an original subvolcanic tourmaline-rich sill but rather a highly boron-metasomatized subvolcanic sill. The mafic composition makes it highly unlikely that this represents a later eutectic-derived and emplaced body as quartz would be expected to be present in much higher amounts. The rock's fabric is that of a coarse-grained, hypidiomorphic granular intrusive. Gold migration was obviously a part of the metasomatic process as attested by its presence in above-normal concentrations.

3.3.3 Subvolcanic Intrusive, Good Claim

This occurrence is also only found in one outcrop located in the north central area of the Good claim. It is found within the Cockeram Lake volcanic unit (2) and near the northern boundary of the Fraser Lake-Eldon Lake volcaniclastics (unit 9). A large body of gabbro (unit 13) is just to the north.

The outcrop appears as a low, rounded, exposure of dark grey-green rock. Linear, coarse-grained, chloritized amphiboles are present with a foliation that is parallel to the regional foliation. The contact appears conformable and is probably a sill.

Thin-section analysis (Table 22) reveals a preponderance (82.6%) of amphiboles. The hornblende is medium-grained (to 2.1mm), euhedral to subhedral, slightly green pleochroic and poikiloblastic with opaques. Abundant sericite, chlorite and calcite alteration are present, with some fibrous actinolite within the highly altered areas. The opaques have the composition of ilmenite. Interstitial untwinned plagioclase is also present in trace amounts.

The sample is very mafic (SiO_2=49.1%) and is a normative gabbro. The sample is very interesting chemically (Table 23) because of its relatively high K_2O content (.88%) as well as Au (72ppb), As (350 ppm), Cr (790ppm) and Ni (260 ppm). The sample is olivine-normative and has a very high normative color index (65.4). In addition, it has unique AFM and YTC plots (Figure 18).

This exposure probably also represents a highly metasomatically altered subvolcanic diabasic intrusive. Modal quartz is very low and should be found in major proportions if this sill was derived from a eutectically melted source. The fabric is also that of a hypidiomorphic granular intrusive. Gold migration and deposition has also been part of the metasomatic alteration process with this unit.

3.3.4 Gabbro (unit 13)

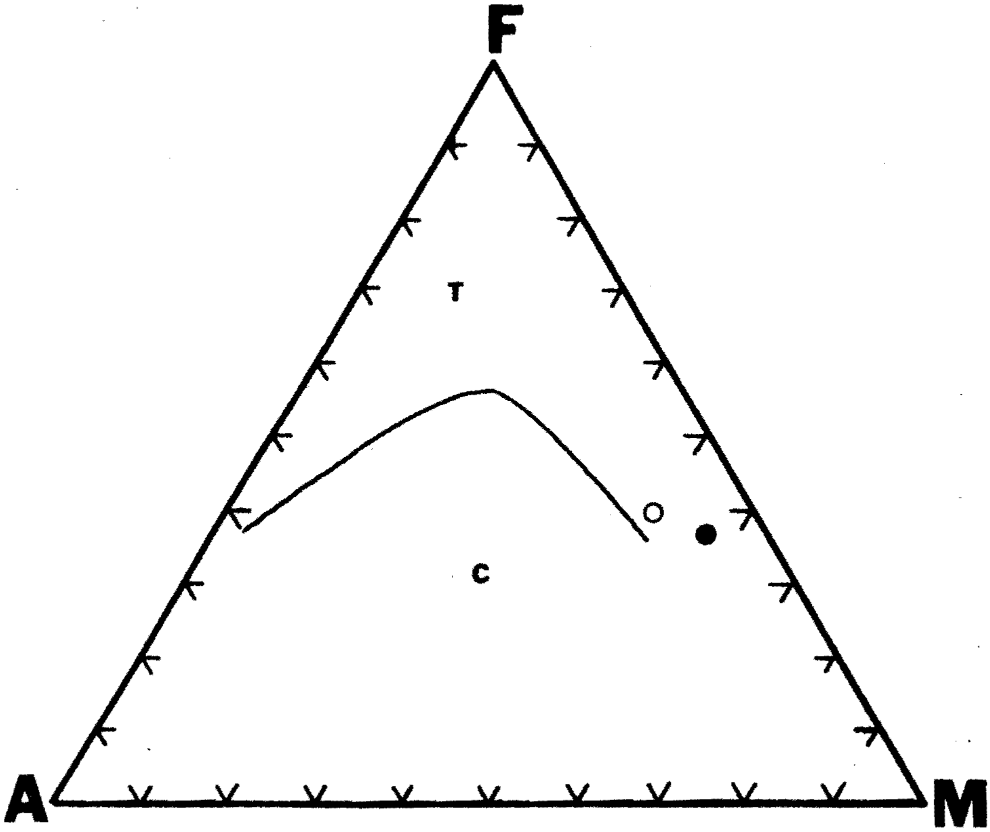
3.3.4.1 Occurrence

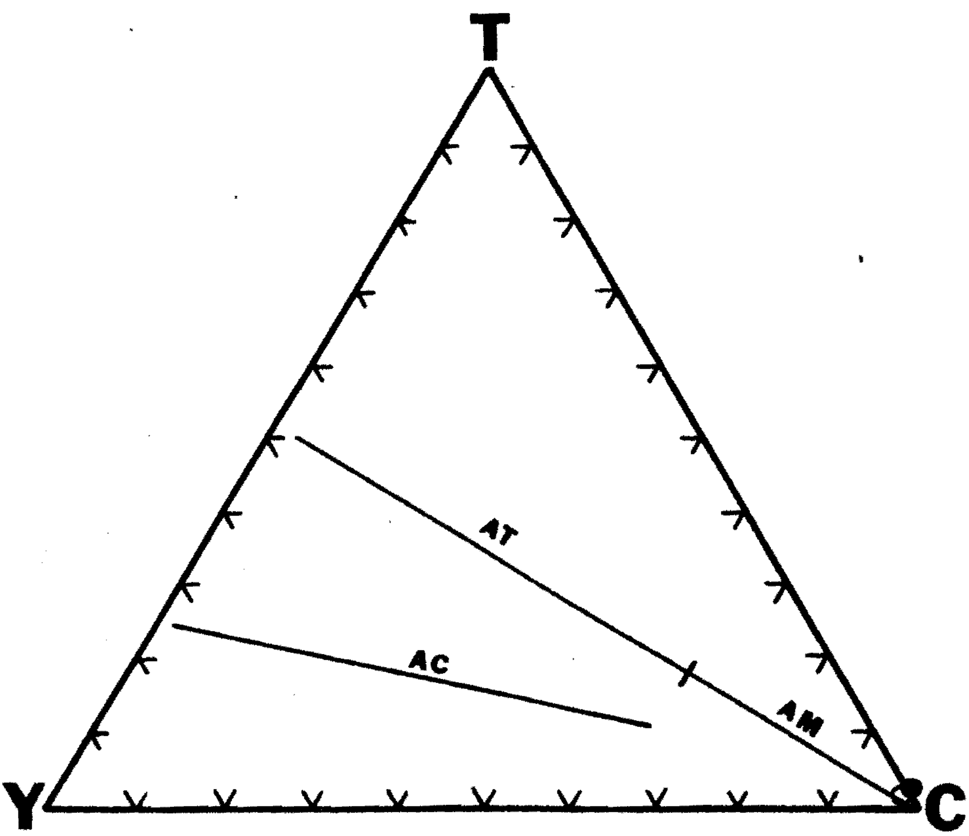
A long linear gabbroic body occurs to the north of most of the claim group and can be found in the northern portion of both the Good and Viggen claims. Its southern contact is with the Cockeram Lake volcanic rocks (unit 2); to the north it is in contact with unit 16 felsic intrusives.

Figure 18: AFM and YTC plots for unit 1 samples. A = $Na_2O + K_2O$, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1979).

○ Tourmaline-bearing subvolcanic intrusive-Rabbit's claim (unit 1)

● Subvolcanic intrusive-Good claim (unit 1)


F
T
C
A
M


T
AT
AC
AM
Y
C

3.3.4.2 Field Relations

On outcrop, the exposures have a well rounded, medium to dark grey appearance. Medium- to coarse-grained, euhedral hornblende pseudomorphs after pyroxene occur with interstitial plagioclase. Abundant biotite occurs in sheared areas. The crystal size becomes finer grained near the contact with the Cockeram Lake basalts and much shearing is associated with this boundary.

3.3.4.3 Mineralogy and Chemistry

Amphibole is the most abundant mineral present (mean=56.6%) (Table 24). It occurs as a medium- to coarse-grained (to 9mm), subhedral, green-brown pleochroic hornblende (Table 25) which is pseudomorphic after pyroxene. Many of the amphibole cores contain highly altered (chloritized) areas which are probably remnant uralitized and chloritized augite. The amphiboles are porphyroblastic and poikiloblastic with plagioclase and opaques.

Medium-grained (to 2.5mm), anhedral, albite-twinned, highly altered (saussuritized), plagioclase is interstitial to the hornblende with some large, anhedral, crystals within the hornblende porphyroblasts. Microprobe analysis determined an anorthite content of An_{51} (andesine) for these feldspars (Table 25). Fine-grained (to .2mm), anhedral opaques occur along amphibole grain boundaries and within the plagioclase.

TABLE 24

Point Counted Modes and Average, Visually Estimated Modes of Gabbro (unit 13)

UNIT	13	13	13
SAMPLE	012	145B	Mean N=4
Quartz	-.-	-.-	1.8
Plagioclase	13.2	33.4	35.2
White Mica	1.2	pr.	2.4
Cholorite	.2	5.2	1.4
Amphibole	82.4	58.8	56.6
Epidote	.8	1.2	.7
Carbonate	2.0	.2	2.3
Opaques	.2	1.2	1.4
Augite	pr.	-.-	pr.
Biotite	pr.	-.-	pr.
Apatite	pr.	-.-	pr.

pr. - present

TABLE 25

Typical Chemical Composition of Unit 13 Minerals

SAMPLE	PLAGIOCLASE	AMPHIBOLE	EPIDOTE
SiO2	54.8	49.2	37.4
Al2O3	26.2	5.3	26.8
FeO	0.1	14.3	6.7
MgO	-.-	10.2	0.1
CaO	9.9	12.4	24.6
Na2O	5.2	0.9	-.-
K2O	-.-	0.2	0.1
TiO2	-.-	0.3	0.1
P2O5	-.-	-.-	0.1
MnO	-.-	0.3	0.1
ClO	-.-	-.-	-.-
SO3	-.-	-.-	0.1
OXYGEN	3.9	6.8	3.9
TOTAL	100.0	100.0	100.0
SI	9.43	6.72	2.86
AL	5.31	0.56	2.42
FE	0.02	1.64	0.43
MG	-.-	2.08	0.01
CA	1.81	1.82	2.02
NA	1.73	0.23	-.-
K	-.-	0.03	0.01
TI	-.-	0.03	0.01
P	-.-	-.-	0.01
MN	-.-	0.03	0.01
CL	-.-	-.-	-.-
S	-.-	-.-	0.00
O	32.0	24.0	13.0
	Ab 48.7 An 51.3	AR=55.5	
NAME	Andesine	Hornblende	Epidote

AR - amphibole ratio

Chlorite (prochlorite) occurs as an alteration on the hornblende and epidote; calcite and muscovite occur as alterations of the plagioclase. Small amounts of zircon, apatite and quartz interstitial to plagioclase are also present. All examples have an idiomorphic and porphyritic fabric.

These rocks contain rather high Cr (greater than 140ppm) and Ni (greater than 14ppm) (Table 26). Most are olivine-normative and have a rather high normative color index (greater than 40). AFM and YTC diagrams indicate a thoeliitic affinity (Figure 19). The samples are normatively gabbro with quartz monzogabbro the one exception. The almost complete absence of modal quartz and potassium feldspar results in the rocks falling within the gabbro region of Streckeisen's (1973) classification which is consistent with the normative rock classification.

3.3.5 Felsic Intrusives (unit 16)

3.3.5.1 Occurrence

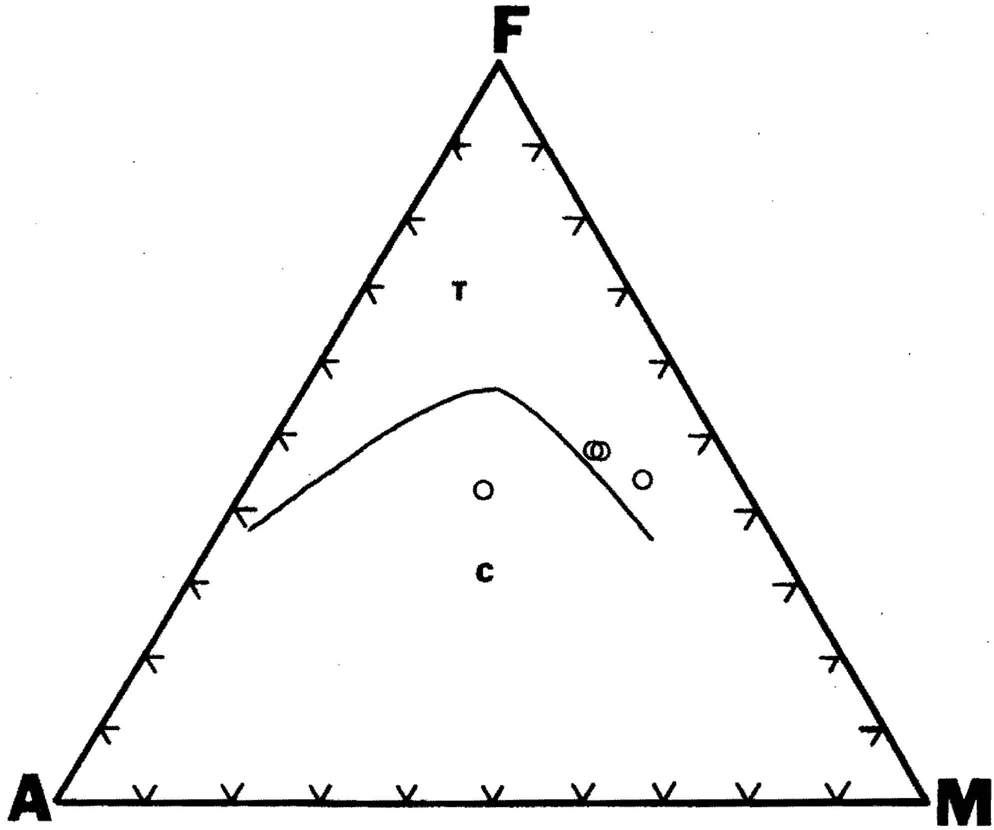
Large felsic intrusive bodies occur north and south of the map area. Unit 16 felsic intrusives are found north of the Rabbit's claim and along the northern border of the Viggen claim.

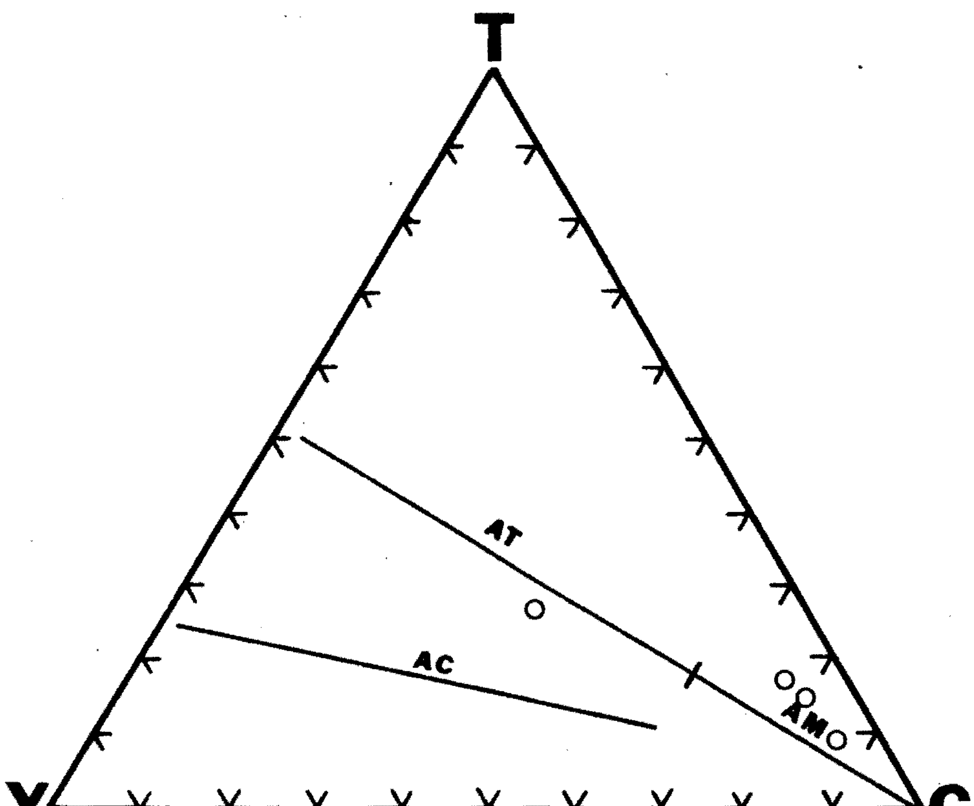
TABLE 26

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Gabbro (unit 13)

SAMPLE	012	145B
SiO2	49.76	49.81
Al2O3	9.54	16.53
Fe2O3	2.76	2.34
FeO	9.64	9.31
CaO	11.92	9.90
MgO	12.02	7.89
Na2O	1.72	2.84
K2O	0.52	0.32
TiO2	1.25	0.78
P2O5	0.60	0.09
MnO	0.22	0.18
Cu	56.0	86.0
Ag	<.5	<.5
Au	<.2	<.2
Zn	19.0	22.0
Y	30.	20.
Pb	4.	4.
Zr	50.	20.
As	4.	4.
Sb	.2	1.0
V	250.	260.
Cr	311.	103.
Mo	2.5	5.0
Co	9.5	14.0
Ni	25.0	42.0
OR	3.06	1.91
AB	15.00	24.02
AN	16.53	31.42
DI	31.24	13.98
HY	20.57	14.27
OL	5.82	9.31
MT	4.00	3.39
IL	2.38	1.48
AP	1.42	0.22
CI	64.01	42.44

Figure 19: AFM and YTC plots for unit 13 samples. A = Na_2O + K_2O, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1979).


F
T
C
A
M


T
AT
AC
AM
Y
C

3.3.5.2 Field Relations

Gilbert et al. (1980) assign unit 16 to a post-Wasekwan, pre-Sickle age. The post-Wasekwan relationship is evident where unit 16 is found intruding the Wasekwan McVeigh Lake volcanic rocks north of the Rabbit's claim. Extensive, small felsic dikes and autoclastic breccias occur in this area and result from the intrusive event. In the northern portion of the Viggen claim, the felsic intrusives have a southern contact with gabbro (unit 13) and probably post-date this intrusion.

On outcrop, unit 16 appears as a low, rounded, medium to light grey, exposure. A secondary foliation is usually developed. Medium-grained plagioclase, quartz, microcline and biotite are present.

Unit 16 is divided into three members based on modal mineral percentages (Table 27). The divisions are: tonalite (unit 16a), quartz monzodiorite (unit 16b) and granodiorite (unit 16c) (Figure 20). This slight modal difference is also apparent in the norms. The differences could be accounted for by multiple injections of slightly differing intrusions, chemical differences due to country rock contamination during intrusion, or as an ion migration zonation produced during metamorphism. In any case, 16a, 16b and 16c are very closely related genetically and can, for the most part, be treated together.

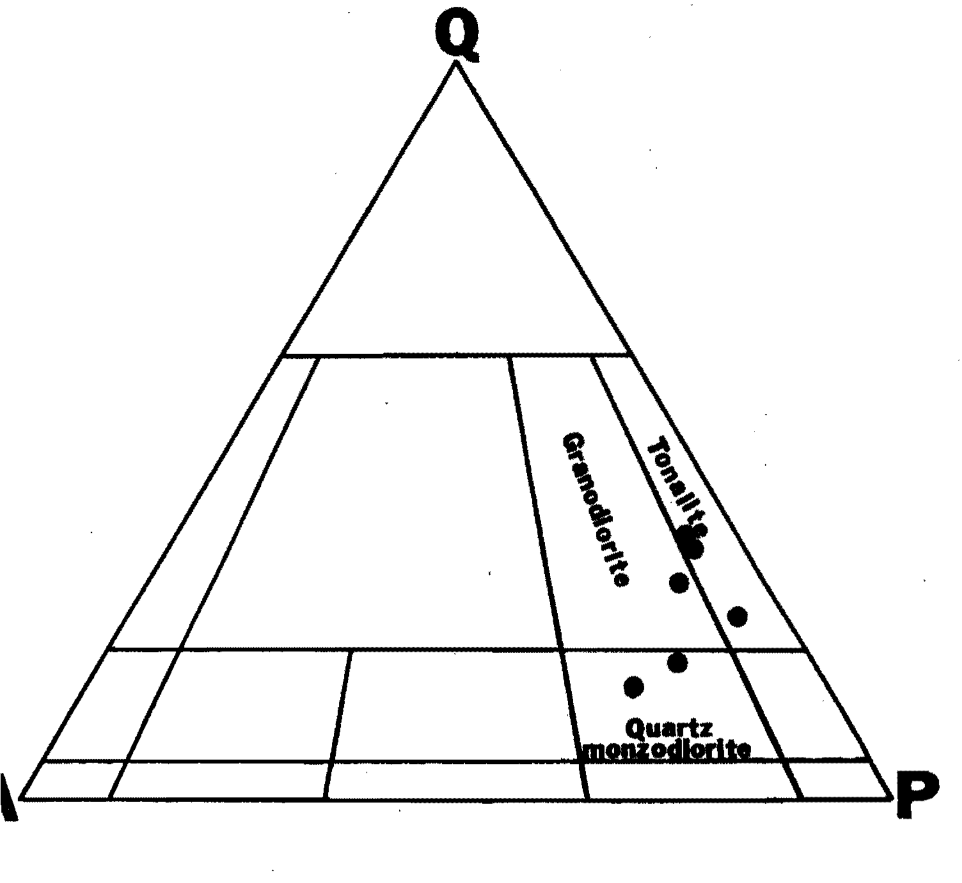
TABLE 27

int Counted Modes of Unit 16 and Visually Estimated Modes for Unit 17

IT	16a	16b	16b	16c	17	17
MPLE	024	026	027	036	101	109
artz	32.8	16.0	13.4	31.2	13.0	25.0
ite ca	7.2	13.8	11.6	15.2	1.0	8.0
ag	53.2	55.0	54.6	51.4	49.0	32.0
aque	.2	-.-	-.-	-.-	pr.	pr.
spar	4.4	12.8	18.4	6.0	30.0	35.0
otite	2.0	.2	.6	-.-	4.0	1.0
lanite	.2	-.-	-.-	-.-	-.-	-.-
idote	pr.	2.	pr.	.6	1.0	-.-
rcon	pr.	pr.	-.-	pr.	pr.	pr.
atite	pr.	pr.	-.-	pr.	pr.	-.-
lorite	-.-	.2	-.-	-.-	-.-	-.-
lcite	-.-	-.-	1.4	.8	2.0	-.-

. - present

Figure 20: Streckeisen plot for unit 16 samples. Q = quartz, A = alkali feldspars, P = plagioclase, all given in modal percentages and normalized such that Q + A + P = 100% (Streckeisen, 1973).


Q
Granodiorite
Tonalite
Quartz monzodiorite
P

.3.5.3 Mineralogy and Chemistry

Modal plagioclase (Table 27) is a very abundant mineral n unit 16. It generally appears as medium-grained (to .1mm), anhedral, Carlsbad, albite- and polysynthetically-winned, normal with minor reverse zoned oligoclase (An_{25}) Table 28). It is usually highly saussuritized with abun-ant overgrowths and bent and broken grains that are healed" with albite. Some microcline inclusions can be ound within the larger grains. In subunit 16b, there ppears to be abundant epidote "exsolution" from the plagi-clase.

Quartz is another modally abundant mineral. It is usu-lly fine-grained (to .8mm) and anhedral. Most of the uartz appears to have been remobilized and is found as eins that crosscut the plagioclase and microcline. Units 6a and 16c have rare myrmekitic quartz occurrences.

Microcline is always present in these rocks, usually as ine- to medium-grained (to 4mm), anhedral, unaltered crys-als that contain the polysynthetic gridiron twinning. Its ccurrence is usually as resorbed inclusions within plagi-lase cores.

Muscovite is very common, with fine- to medium-grained ystals. These crystals are usually very strained and bent d typically contain minor zircon haloes. Biotite, epi-te, zircon, apatite and calcite can usually be found in nor quantities.

TABLE 28

ical Chemical Compsitions of Unit 16 Intrusive Minerals

LE	FELDSPAR	PLAG	APATITE	EPIDOTE	ALLANITE	BIOTITE
	64.06	60.27	0.24	37.14	6.90	34.77
3	18.70	23.44	-.-	23.61	6.66	16.57
	-.-	0.12	0.18	11.84	2.81	24.39
	0.14	0.10	-.-	0.22	0.93	6.18
	-.-	5.62	57.62	24.20	6.26	0.10
	0.53	7.12	-.-	0.15	-.-	0.38
	16.81	-.-	-.-	-.-	-.-	10.18
	0.23	0.08	-.-	-.-	-.-	3.19
	-.-	-.-	43.61	-.-	-.-	-.-
	-.-	-.-	-.-	0.11	-.-	0.47
	-.-	-.-	-.-	-.-	0.06	-.-
	-.-	-.-	-.-	-.-	-.-	-.-
EN	-.-	3.25	-.-	2.72	76.38	3.73
L	100.5	100.0	101.6	100.0	100.0	100.0
	11.85	10.29	0.04	2.97	0.28	5.40
	4.08	4.71	-.-	2.22	0.32	3.03
	-.-	0.02	0.03	0.79	0.09	3.17
	0.04	0.03	-.-	0.03	0.06	1.43
	-.-	1.03	10.39	2.07	0.27	0.02
	0.19	2.36	-.-	0.02	-.-	0.11
	3.97	-.-	-.-	-.-	-.-	2.02
	0.03	0.01	-.-	-.-	-.-	0.37
	-.-	-.-	2.61	-.-	-.-	-.-
	-.-	-.-	-.-	0.01	-.-	0.06
	-.-	-.-	-.-	-.-	0.00	-.-
	-.-	-.-	-.-	-.-	-.-	-.-
	32.0	32.0	26.0	13.0	13.0	24.0
	Or 95.4 An 4.6	Ab 69.6 An 30.4				
;	Micro-cline	Andesine	Hydroxy-apatite	Epidote	Allanite	Biotite

An interesting distinguishing feature of subunit 16a is that the rare earth mineral allanite is always present in small amounts. The mineral is completely metamict with fractures radiating into the surrounding rock. The mineral is dark green and euhedral with a hexagonal crystal form (Figure 21). Qualitative microprobe analysis (Table 28) indicates that the elements it contains, in order of decreasing abundance, are: Si,Al,Ce,Ca,La,Th,Fe,Cl. No such mineral occurrence is noted within subunits 16b or 16c, indicating that 16a may be a separate intrusive. All unit 16 rocks have an idiomorphic to hypidiomorphic granular, subporphyritic texture and the matrix minerals appear crushed to some degree. Hydrothermal alteration appears to have played a role in minor mineral alteration.

Unit 16 members appear very similar chemically with all containing between 67% and 69% SiO_2; all are quartz and corundum normative (Table 29). All also have a low normative color index (approximately 6.5).

1.3.6 Felsic Intrusive (unit 17)

1.3.6.1 Occurrence

Unit 17 occurs in the southernmost portions of abbit's, Luck, Tornado, Mirage, and K-fir claims and is ound in the south central portion of the Good claim.

Figure 21: Photomicrograph of metamict allanite crystals (left and top center) from tonalite (subunit 16a) sample 33. Note quartz and sericitized plagioclase (anhedral grey grains) as well as muscovite (lower right). Crossed polars, 353x.

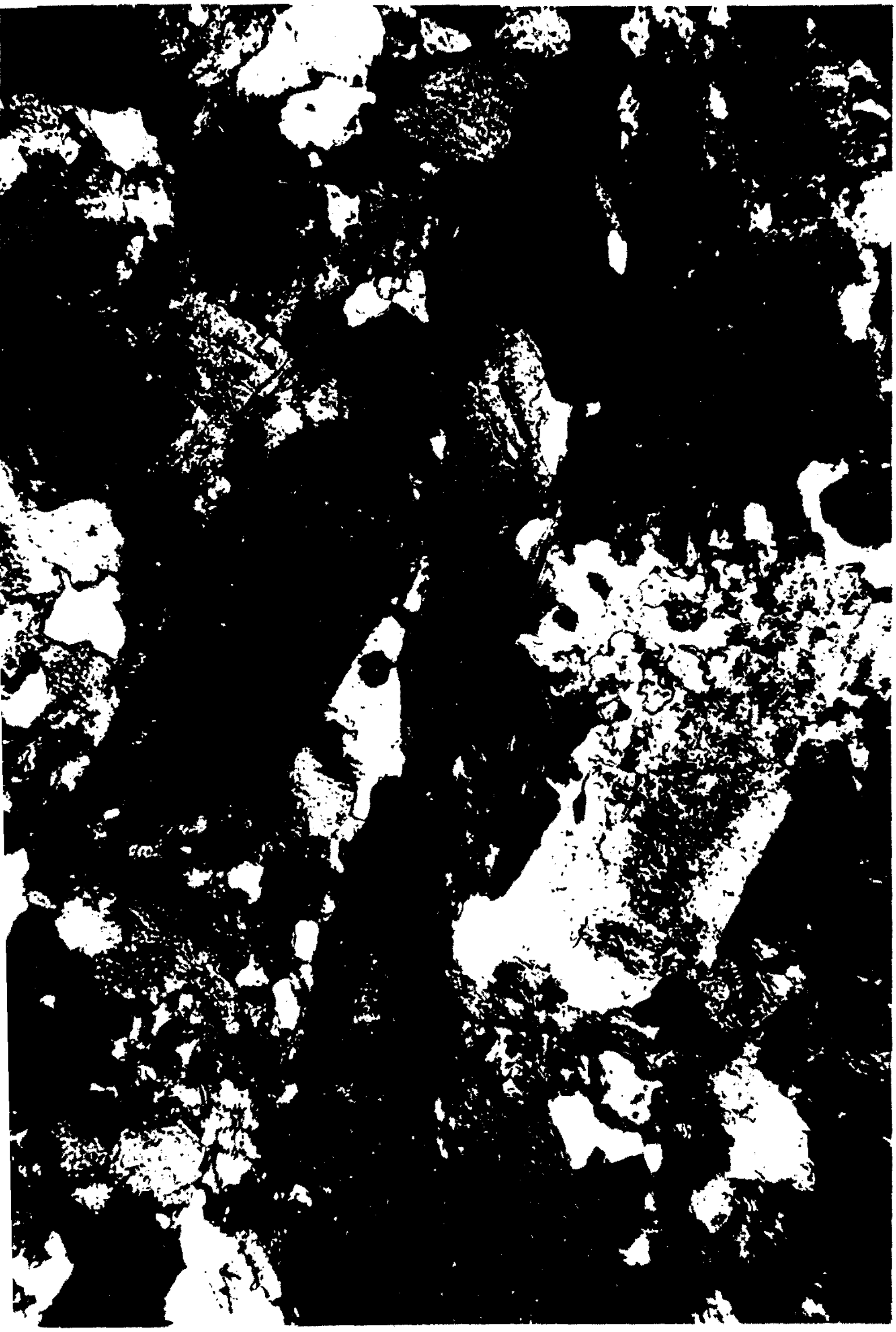


TABLE 29

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Units 16 and 17

UNIT	16a	16b	16c	17	17
SAMPLE	033	027	036	086	101
SiO2	68.47	69.39	68.53	71.73	70.29
Al2O3	16.48	16.81	16.56	15.50	16.28
Fe2O3	1.87	0.30	1.54	1.57	1.35
FeO	1.56	2.25	1.86	0.52	0.52
CaO	2.46	1.92	2.04	2.45	3.08
MgO	1.00	0.73	1.01	0.55	0.69
Na2O	4.58	4.74	4.69	5.22	4.25
K2O	3.04	3.43	3.22	2.10	3.19
TiO2	0.34	0.28	0.34	0.26	0.25
P2O5	0.14	0.11	0.14	0.06	0.06
MnO	0.06	0.05	0.05	0.04	0.04
Cu	37.0	2.5	8.0	6.0	3.0
Ag	<.5	<.5	<.5	<.5	<.5
Au	<2.	<2.	<2.	71.	<2.
Zn	50.0	40.0	58.0	19.0	27.0
Y	20.	20.	10.	0.	0.
Pb	8.	8.	10.	4.	4.
Zr	180.	130.	170.	80.	70.
As	1.	5.	6.	3.	3.
Sb	.2	.6	.9	.4	.5
V	31.	24.	33.	24.	26.
Cr	44.	41.	48.	44.	44.
Mo	6.5	3.0	3.5	3.0	3.0
Co	1.5	6.5	6.5	2.0	3.5
Ni	5.5	6.0	6.0	4.0	5.0
QZ	23.41	22.21	22.69	27.44	25.90
CO	1.52	2.09	2.00	0.34	0.39
OR	17.97	20.29	19.03	12.40	18.88
AB	38.80	40.07	39.68	44.17	35.93
AN	11.25	8.77	9.17	11.75	14.88
HY	3.36	5.35	4.21	1.36	1.72
MT	2.72	0.43	2.24	1.05	1.08
HM	-.-	-.-	-.-	0.85	0.61
IL	0.64	0.53	0.65	0.49	0.47
AP	0.34	0.27	0.34	0.15	0.15
CI	6.72	6.30	7.09	3.75	3.87

.3.6.2 Field Relations

Unit 17 has also been assigned a pre-Sickle, ost-Wasekwan age. Again, the field relationship of this nit verifies this age. In the southeast portion of the abbit's claim, the unit appears to be a highly sheared atholith intruded into the Fraser Lake-Eldon Lake volcanic-astics (unit 9). From the eastern end of Foster Lake to ne easternmost extent of the map area, the unit appears to e a highly sheared felsic sill that has northern contacts ith the Fraser Lake-Eldon Lake volcaniclastics (unit 9), raser Lake mafic volcanic rocks (unit 4) and Pole Lake ntermediate volcanic rocks (unit 5), from west to east. ne average width of this sill is about 114m. The extent of nis highly sheared sill defines the extent of the artwright Lake shear zone. The apparently conformable elationship with the units to the north and highly sheared ature of the sill suggests emplacement during the shearing vent. This would provide the necessary long plane of weak-ess to be intruded and yet still account for the very high nount of shearing present within the sill itself. The con-ict with surrounding volcanic and volcaniclastic rocks is a ry highly sheared biotite-rich zone a few centimeters de. No invasion within the northern units is found. placement at relatively low temperatures also is evident om the absence of baked contacts.

Outcrops appear very sheared, weathered and are easily recognizable by their frost-heaved nature (Figure 22). Quartz stringers are very common. Larger, more resistant microcline augens occur in a groundmass composed of quartz, plagioclase and biotite. Foliation is very well developed.

3.3.6.3 Mineralogy and Chemistry

The typical mineralogy of unit 17 (Table 27) contains abundant plagioclase. Two types are present. Oligoclase occurs as fine- to medium-grained (to 1.22mm), anhedral, albite-twinned, poikiloblastic, slightly sericitized, normally-zoned grains. Alteration is more pronounced toward the cores of these grains. More sodic, unaltered overgrowths are very common. A fine- to coarse-grained (to 2.5mm), porphyroblastic, anhedral, untwinned, secondary albite is more common than the oligoclase. The largest of the porphyroblasts appeared to be a replacement of original microcline. Abundant small muscovite flakes and "needles" occurred at right angles to each other and exhibited a "weave" or "quiltwork" pattern within the feldspars. Microprobe analysis (Table 30) derived a composition of Ab_{87} for this albite.

Microcline (Table 30) is observed as fine- to coarse-grained (to 1.22mm), anhedral, gridiron-twinned, sheared, slightly sericitized patches that are highly adsorbed by albite (Figure 23). The original percentage of

TABLE 30

Typical Chemical Composition of Unit 17 Minerals

SAMPLE	FELDSPAR	PLAGIOCLASE	OPAQUE
SiO2	62.7	64.7	0.1
Al2O3	18.0	20.6	0.3
FeO	-.-	0.2	92.8
MgO	-.-	-.-	-.-
CaO	-.-	2.1	-.-
Na2O	0.4	8.4	-.-
K2O	16.9	0.1	-.-
TiO2	0.4	-.-	-.-
P2O5	-.-	-.-	-.-
MnO	0.1	-.-	0.2
ClO	-.-	-.-	-.-
SO3	-.-	-.-	0.2
OXYGEN	1.42	4.04	6.35
TOTAL	100.0	100.0	100.0
SI	11.50	10.81	0.04
AL	3.90	4.05	0.11
FE	-.-	0.02	24.11
MG	-.-	-.-	-.-
CA	-.-	0.38	-.-
NA	0.13	2.71	-.-
K	3.96	0.03	-.-
TI	0.05	-.-	-.-
P	-.-	-.-	-.-
MN	0.02	-.-	0.05
CL	-.-	-.-	-.-
S	-.-	-.-	0.06
O	32.0	32.0	32.0
	Or 96.8 Ab 3.2	Or .8 Ab 87.0 An 12.2	
NAME	Microcline	Albite	Magnetite

Figure 22: Exposure of frost-heaved, sheared granodiorite (unit 17) within an area of the Cartwright Lake shear zone. This exposure is found at location 52 near the southern Luck claim line (plate I).

ocline was probably higher, but much albite replacement occurred.

Quartz is found to be fine- to medium-grained (to m) and anhedral. It occurs as sheared grains, in veins as myrmekitic inclusions in plagioclase. Quartz veining :-dates all other events.

Muscovite occurs as fine-grained (to .06mm) subhedral kes. It is found within the plagioclase as previously ed and as separate grains that are bent around plagi-ase augens.

Opaques are fine- to medium-grained (to .3mm) and found be embayed by quartz and albite along cleavage planes. netite is the dominantly occurring species. Traces of con and biotite are also found.

The rock fabric is always porphyroblastic, poikiloblas- and cataclastic. Flaser structure is very common.

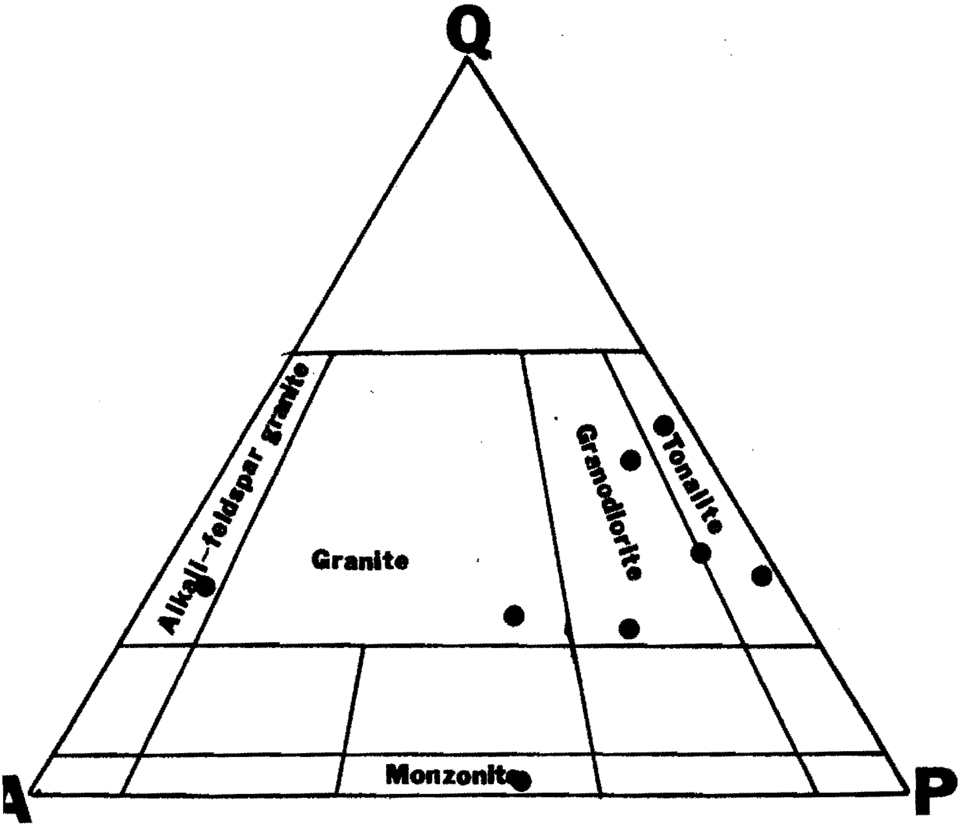
Unit 17 appears to have more SiO_2 and less MgO and FeO n unit 16 (Table 29). Less Zr (less than 90ppm) is also dent. Metasomatic effects are very evident; the dominant cess was potassium, sodium and silicon metasomatism. d migration and deposition accompanied these processes resulted in very high gold contents (up to 71ppb).

This unit always contains normative quartz and corundum has a very low normative color index (approximately 3-4) ble 29). Due to extensive hydrothermal alteration, the al content of the unit varies greatly (Figure 24).

Figure 23: Photomicrograph of flaser structure within granodiorite (unit 17) sample 109. Note gridiron twinned microcline which exhibits untwinned, albitized edges. Crossed polars, 139x.

Chemically (normatively), a single granodiorite composition is assigned all the samples. This probably reflects the true primary composition of the body.

Figure 24: Streckeisen plot for unit 17 samples. modal percentages and normalized such that Q + A + P = 100% (Streckeisen, 1973).


Q
Alkali-feldspar granite
Granite
Granodiorite
Tonalite
Monzonite
A
P

Chapter IV

PETROLOGY AND GEOCHEMISTRY OF ROCKS NEAR MINOR GOLD OCCURRENCES

4.1 BROWN SHOWING

The Brown showing occurs in the west central portion of the Rabbit's claim. In the early literature (Bateman, 1945 and Milligan, 1960), this showing is referred to as the Ace group discovery.

This showing consists of thirteen trenches nine of which were examined during this study. Regionally, these trenches are within the confines of the Fraser Lake mafic volcanic body (unit 4), more specifically within the Fraser Lake porphyritic basalt member (subunit 4e). On a local scale (Plate II), the area contains Fraser Lake mafic volcanic rocks (units 4d and 4f), Fraser Lake-Eldon Lake volcaniclastic rocks (units 9a, 9b) and intrusive rocks (units 22a, 22b) which contain quartz veins that assay very high gold contents.

The Brown showing occurs in an area of structural complexity with broad drag-folding evident from mapping studies. Complex shearing is also prevalent, both within the wall rocks and within the intrusive rocks. The attitudes of the units also indicate great structural complexity with nearby units dipping in opposite directions. This is especially evident in the southwest portion of the area (Plate II).

4.1.1 Fraser Lake Mafic Volcanic Rocks (unit 4)

4.1.1.1 Fraser Lake Amygdaloidal Basalt (subunit 4d)

Amygdaloidal, porphyritic basalt appeared as a low, resistant, rounded outcrop and is found in the southernmost portion of the mapped area.

The mineralogical make-up of this unit is very similar to the Fraser Lake porphyritic basalt (subunit 4e) of the regional studies but this particular location also contains amygdales. The exposure contains a large percentage of fine-grained (to .45mm), subhedral, blue-green pleochroic, amphibole (Table 31). Fine to medium-grained (to 2.2mm), anhedral, plagioclase also occurs in abundance. Most is present as fine-grained, untwinned, mosaic groundmass but a few percent of medium-grained, albite- and Carlsbad-twinned, normally zoned plagioclase porphyroblasts occur. Overgrowths and sausseritization are common. The typical "relict" opaques are also present. Polymineralic and polycrystalline quartz amygdales (approximately 15%) which exhibit a deformed, elliptical shape, occur in the rock. The remaining mineralogy is indistinguishable from the surrounding regionally extensive porphyritic basalts of subunit 4e.

TABLE 31

Point Counted Modes and Average, Visually Estimated Modes of Brown Showing Volcanic and Volcaniclastic Rocks (subunits 4d, 4f, 9a, 9b)

UNIT	4d	4f	9a	9a	9a	9b	9b
SAMPLE	189	178	183	194	$\bar{X}$ N=7	175A	$\bar{X}$ N=2
Quartz	9.2	17.4	30.0	3.8	21.7	75.0	75.0
Plagioclase	32.8	15.2	2.2	30.4	16.7	1.0	.05
White Mica	pr.	4.2	pr.	pr.	6.9	22.8	21.4
Cholorite	6.0	1.4	4.8	15.4	8.8	-.-	-.-
Amphibole	46.6	59.0	61.8	34.0	37.8	-.-	2.0
Epidote	.6	-.-	-.-	-.-	.01	-.-	.05
Carbonate	2.4	.2	-.-	14.0	3.6	-.-	-.-
Opaque	2.4	2.6	1.2	2.4	3.9	.8	.9
Garnet	-.-	-.-	-.-	-.-	-.-	.4	.2
Biotite	-.-	-.-	-.-	-.-	-.-	-.-	.05

$\bar{X}$ - mean
pr. - present

Chemically (Table 32), the Brown showing amygdaloidal isalts (subunit 4d) contain much more K_2O (1.7%) than the rerage unit 4 basalts. This most likely is the result of a ervasive potassium metasomatism through the area. Minor .ements also occur in a rather anomalous pattern with more ian normal Cu, Ag, Au, Zn, Pb, Zr, As and Co and less than ›rmal Sb and Ni. Subunit 4d, like most subunit 4e regional ialyses, is quartz normative. Both AFM and YTC diagrams 'igure 25) show a tholeiitic character for both subunit 4d id subunit 4e basalts. The composition can range from a orite through a quartz diorite and to a tonalite composi-on.

Subunit 4d always exhibits an amygdaloidal, porphyrob-stic, gneissic fabric with local shearing and occasional toclastic breccia clasts contained within the unit. The own occurrence is therefore very similar to that of gionally occurring 4e with the exception of amygdales and eccia clasts.

1.1.2 Fraser Lake Mafic Tuff (subunit 4f)

Mafic tuff occurred at the Brown showing as a fine-ained, hornfelsic, medium to dark grey, folded unit with lcite and quartz veins up to 3.8 cm wide. This tuff is e northernmost unit mapped within the area.

More modal quartz, amphibole and opaques, and less pla-oclase, micas and epidote are found locally than in the

TABLE 32

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Brown Showing Volcanic and Volcaniclastic Rocks (subunits 4d, 4f, 9a and 9b)

UNIT	4d	4f	9a	9a	9b	9b
SAMPLE	189	178	185	188	175A	191
SiO2	52.24	53.00	54.30	53.89	67.23	64.35
Al2O3	16.04	15.39	14.14	15.16	16.76	17.04
Fe2O3	3.00	2.00	2.86	2.62	1.03	1.46
FeO	10.15	10.74	11.54	11.37	3.78	4.11
CaO	7.60	7.52	8.39	6.44	2.32	3.39
MgO	4.48	6.06	4.06	4.84	1.20	2.18
Na2O	2.95	2.98	2.31	3.27	5.30	5.08
K2O	1.70	0.89	0.71	0.66	1.63	1.53
TiO2	1.45	1.10	1.32	1.41	0.54	0.62
P2O5	0.18	0.10	0.15	0.14	0.10	0.13
MnO	0.22	0.21	0.24	0.19	0.10	0.12
Cu	130.	81.0	140.	150.	18.0	4.0
Ag	.5	<.5	1.0	1.0	.5	<.5
Au	81.	<2.	51.	22.	30.	12.
Zn	56.0	37.0	41.0	44.0	68.0	25.0
Y	30.	30.	10.	30.	20.	40.
Pb	15.	4.	47.	25.	4.	23.
Zr	100.	50.	50.	110.	170.	130.
As	12.	5.	6.	4.	1.	6.
Sb	.8	.6	.8	.8	.3	.5
V	320.	290.	380.	330.	20.	280.
Cr	38.	44.	44.	41.	27.	38.
Mo	3.0	4.0	3.0	1.0	1.0	5.0
Co	16.0	19.0	14.0	22.0	2.0	10.0
Ni	4.0	12.0	5.0	8.0	<.5	4.0
QZ	2.06	2.13	9.94	5.48	21.21	16.29
CO	-.-	-.-	-.-	-.-	2.29	1.19
OR	10.03	5.25	4.18	3.88	9.66	9.04
AB	24.95	25.18	19.50	27.65	47.87	42.99
AN	25.51	26.02	26.14	24.77	10.84	15.93
DI	9.23	8.81	12.19	5.24	-.-	-.-
HY	20.72	27.38	21.03	26.16	8.36	10.97
MT	4.35	2.91	4.14	3.80	1.50	2.11
IL	2.75	2.08	2.51	2.69	1.03	1.17
AP	0.45	0.24	0.36	0.34	0.24	0.32
CI	37.05	41.18	39.89	37.89	10.89	14.25

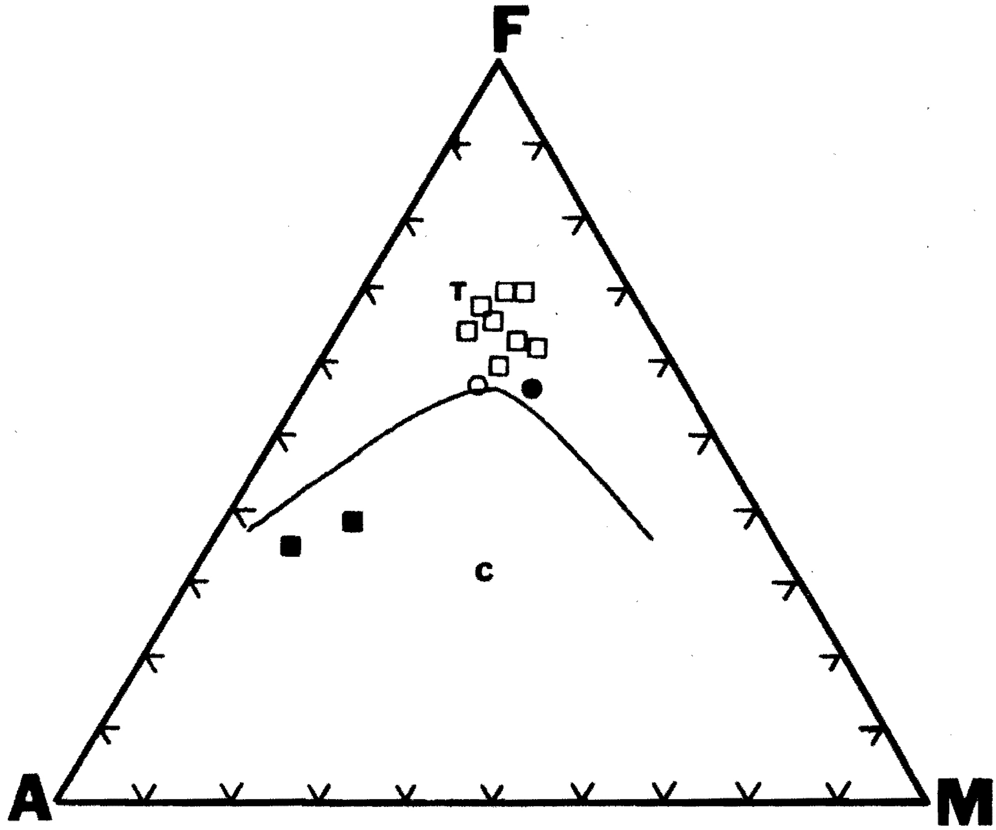
Figure 25: AFM and YTC diagrams for Brown showing units 4 and 9. A = Na_2O + K_2O, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1962).

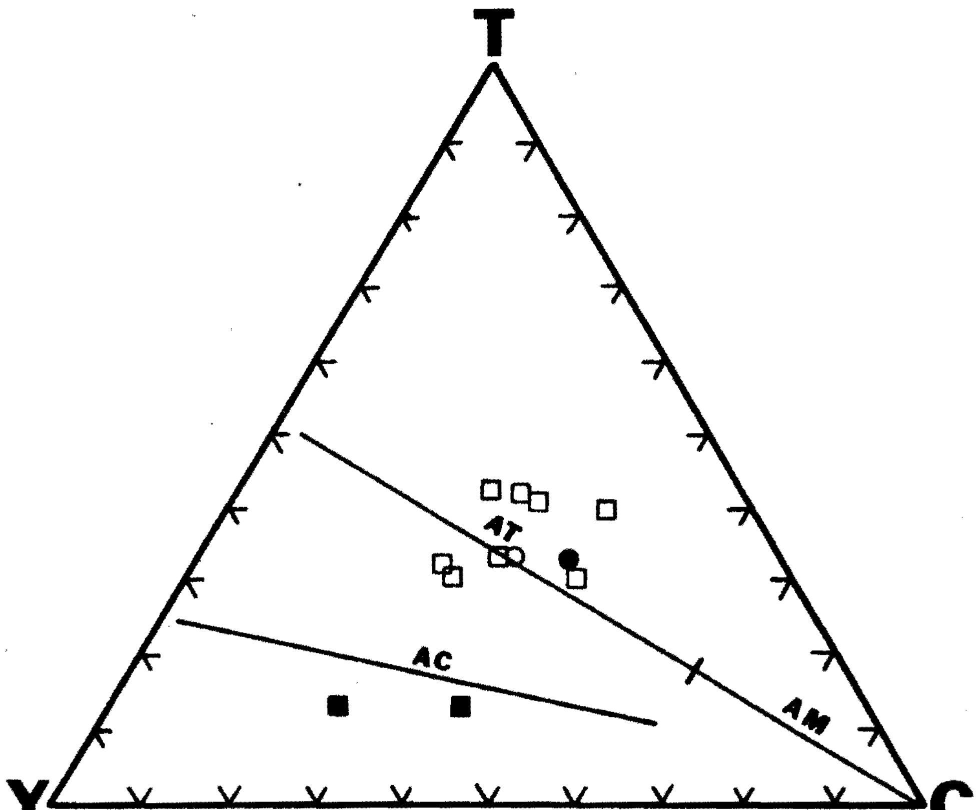
○ Fraser Lake amygdaloidal basalt (subunit 4d)

● Fraser Lake mafic tuff (subunit 4f)

□ Fraser Lake-Eldon Lake hornblende-bearing greywacke (subunit 9a)

■ Fraser Lake-Eldon Lake siltstone (subunit 9b)


F
A
M
T
C


T
Y
C
AT
AC
AM

regional subunit 4f occurrence (Table 31). The dominant amphibole is a medium-grained (to 1mm), anhedral, blue-green pleochroic amphibole. The plagioclase occur as a fine-grained (to .45mm) mosaic with some anhedral, highly sericitized, "clots" that exhibited minor albite twinning. The opaques are again "relict" from original volcanic crystals. Both calcite and chlorite (prochlorite) occur as fracture fillings.

The Brown showing mafic tuffs contain higher amounts of FeO, K_2O and TiO_2 and lower Al_2O_3 contents than did the regional mafic tuffs. For the minor elements, there is a higher content of Cu, Zn, Zr, As, V, Co and Ni and lower Sb (Table 32). Both the regional and local 4f subunits are quartz normative and are tholeiitic according to the YTC diagrams (Figure 25).

4.1.1.3 Fraser Lake-Eldon Lake Volcaniclastic Rocks (unit 9)

Both hornblende-bearing greywacke (subunit 9a) and mica-bearing siltstone (subunit 9b) occur within the mapped area of the Brown showing.

4.1.1.4 Hornblende-bearing Greywacke (subunit 9a)

This unit is located along the southern border of much of the map area. Its contact is with amygdaloidal basalt (subunit 4e) and occasionally with siltstone (subunit 9b) along its southern border and with a quartz diorite intrusive along its northern border.

Most outcrops appear gneissic or hornfelsic, with schistosity becoming dominant as the amount of shearing increases. Quartz, calcite and chlorite veining also become more dominant as this occurs.

Less modal quartz, muscovite, amphibole and epidote and more plagioclase, chlorite, carbonates and opaques are found within this unit (Table 31). The amphibole is again the subhedral to anhedral, medium-grained (to 2mm), porphyroblastic and highly poikiloblastic variety; the only difference is that microprobe analyses give a ferrohastingsite composition (Table 33). Hornblende is the common composition of the regionally occurring subunit 9a amphibole. Most plagioclase occurs as fine-grained, untwinned, mosaic groundmass. Compositions of both An_{30} and An_5 are obtained by microprobe procedures (Table 33). Quartz, calcite and chlorite (penninite) are found within the highly sheared sections of rock as vein and fracture fillings. Evenly distributed anhedral blebs of ilmenite occur throughout both the sheared and unsheared portions of the rocks.

Higher amounts of Cu, Ag, Au, Pb, As, V and Cr are present and less Zn and Sb (Table 32). Except for the specifics mentioned, the local and regional occurrences are chemically very similar. A definite tholeiitic character is displayed on both AFM and YTC diagrams (Figure 25).

TABLE 33

Typical Chemical Composition of Brown Showing Volcaniclastic Minerals (subunits 9a and 9b)

SAMPLE	AMPHIBOLE	PLAG	PLAG	GARNET	BIOTITE	ILMENITE
SiO2	39.7	57.4	62.8	35.2	33.8	0.4
Al2O3	16.1	23.3	18.8	19.2	16.8	0.1
FeO	23.3	0.5	-.-	22.2	23.6	4.49
MgO	3.9	0.2	-.-	0.5	5.6	0.1
CaO	11.1	5.4	0.9	7.5	0.1	0.3
Na2O	1.2	6.8	9.0	-.-	0.3	-.-
K2O	0.4	0.1	-.-	-.-	8.9	0.1
TiO2	0.4	0.1	-.-	0.2	2.8	50.8
P2O5	-.-	-.-	-.-	-.-	-.	-.-
MnO	0.7	0.1	-.-	13.2	0.5	2.2
ClO	0.1	-.-	-.-	-.-	-.-	-.-
SO3	-.-	0.1	-.-	-.-	0.1	0.2
OXYGEN	3.1	6.2	8.5	1.9	7.4	1.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
SI	5.98	9.54	10.02	5.61	4.94	0.02
AL	2.86	4.56	3.54	3.61	2.89	0.01
FE	2.93	0.07	-.-	2.97	2.89	1.85
MG	0.88	0.04	-.-	0.13	1.22	0.01
CA	1.79	0.96	0.15	1.29	0.01	0.02
NA	0.35	2.18	2.78	-.-	0.09	-.-
K	0.07	0.01	-.-	-.-	1.67	0.00
TI	0.05	0.01	-.-	0.03	0.31	1.89
P	-.-	-.-	-.-	-.-	-.-	-.-
MN	0.09	0.01	-.-	1.78	0.06	0.09
CL	0.02	-.-	-.-	-.-	-.-	-.-
S	-.-	-.-	-.-	-.-	0.01	0.01
O	24.0	32.0	32.0	24.0	24.0	6.0
R=	22.6	Ab 69.2 An 30.4 Or .4	Ab 95.0 An 5.0			
AME	Ferro-hastingsite	Oligoclase	Albite	Almandine-Spessertine	Biotite	Ilmenite

R - amphibole ratio

.1.5 Fraser Lake-Eldon Lake Siltstone (subunit 9b)

Mica-bearing siltstone (subunit 9b) occurs in the ıthern portion of the map area. It occurs to the south of e hornblende-bearing greywacke (subunit 9a) and to the th of the amygdaloidal basalt (subunit 4d), but pinches to the northwest.

Its gneissic texture makes it very distinct in the nches. It appears as a light grey to white, laminated mm thick), crenulated, resistant exposure which is schis- e but rarely sheared. The laminations are composed of e-grained, muscovite-rich zones which define relict bed- g.

This local unit has much more quartz (mean=75.0%) and s plagioclase (mean=.5%) (Table 31). The plagioclase is e-grained (to .45mm), anhedral, untwinned, normally zoned forms an annealed mosaic groundmass. A few fine- ined, albite-twinned grains (An_{30}) are found within the covite-rich zones. The one extreme modal difference ween the local and regional 9b subunit is the higher per- tage of garnet in the local occurrences. The garnets are n-rich (almandine) with minor manganese (spessartine) sent (Table 33). Linear trains of opaques parallel to bedding are also common. There is less epidote and car- ate present locally.

The muscovite zones are unique to the outcrops of this a in that the fine-grained mica bands are not found ionally. These bands have small scale crenulations.

Higher SiO_2 and Na_2O and lower Fe_2O_3, FeO, MgO, K_2O, TiO_2 and MnO contents are present. Au, Pb, Zr and Mo are also more enriched, with Cu, Zn, Sb, V, Cr, Co and Ni depleted (Table 32).

Normative quartz and corundum are common to both types of occurrences but the local samples have a lower normative color index (10-14). Both local and regional analyses show a definite calc-alkaline affinity on the AFM and YTC diagrams (Figures 25 and 17 respectively).

4.1.2 Intrusives (unit 22)

Two petrologically and chemically distinct intrusives occur within the Brown showing. They are located centrally within the map area, appear to be conformable to the local drag-folding, and do not cross-cut the adjacent volcanic and volcaniclastic units. It appears that two intrusive events occurred which resulted in the emplacement of fine-grained quartz diorite (subunit 22b), followed by a quartz and plagioclase porphyry (subunit 22a) intrusion into this unit. This relationship is shown by the relative location of the two units. The quartz plagioclase porphyry occurs along the northern contact of the quartz diorite in the northwest and is found between quartz diorite units in the southeast. This "crosscutting" relationship implies a younger age for the quartz plagioclase porphyry. Moreover, shearing is dominant within the fine-grained quartz diorite, but not the porphyritic unit.

4.1.2.1 Quartz Plagioclase Porphyry (subunit 22a)

Interpreted as the youngest unit within the area, the quartz plagioclase porphyry also appears to be the least altered. It is quite distinct in outcrop with its medium-grey color, conformable sill-like contacts, and distinct medium- to coarse-grained porphyroblastic quartz and plagioclase crystals. The rock is commonly xenoblastic, somewhat schistose and locally sheared.

Thin section analysis (Table 34) shows a high percentage of fine- to medium-grained (to 2.3mm) plagioclase. The medium-grained plagioclase is porphyroblastic, albite-twinned and shows bent or broken twin lamellae and overgrowths. Some of the larger porphyroblastic grains exhibit myrmekitic inclusions. Microprobe analysis (Table 35) shows an anorthite content of 29.4 (oligoclase). This may not be the original composition, as some of the larger porphyroblasts show minute patches of microcline twinning; albitization of microcline thus may have played a dominant role in the present composition of the porphyroblasts.

Quartz also occurs in major amounts and is usually fine-grained (to .45mm) and anhedral. It can also be found as fine-grained porphyroblasts which exhibit augen shapes, serrate edges and undulose extinction.

Muscovite is also present in major proportions with two generations present. The earlier generation is fine-grained (to .4mm), anhedral, tattered, clear and non-pleochroic, the

TABLE 34

Point Counted Modes and Average, Visually Estimated Modes of Brown Showing Intrusive Unit 22 and Quartz Veins

UNIT	22a	22a	22a	22b	22b	QUARTZ V.
SAMPLE	193	200	Mean N=5	176	179	Mean N=2
Quartz	4.4	5.4	11.6	11.2	12.0	92.5
Plag	78.8	79.6	66.3	53.2	48.0	2.0
K-spar	5.8	.6	3.1	1.0	pr.	-.-
White Mica	7.2	13.8	10.6	34.2	38.2	1.5
Chlorite	2.8	-.-	.6	-.-	-.-	.5
Carbonate	.8	-.-	1.4	-.-	1.8	-.-
Opaque	.2	.6	1.0	.4	pr.	3.5
Biotite	pr.	-.-	5.6	pr.	pr.	-.-
Zircon	pr.	-.-	.9	-.-	pr.	-.-

pr. - present

TABLE 35

Typical Chemical Composition of Brown Showing Unit 22 Minerals

SAMPLE	PLAGIOCLASE	MUSCOVITE	OPAQUE
SiO2	60.8	44.6	0.4
Al2O3	22.8	34.2	-.-
FeO	-.-	2.1	50.6
MgO	-.-	1.1	-.-
CaO	5.4	-.-	-.-
Na2O	7.1	0.4	0.2
K2O	0.1	10.9	-.-
TiO2	-.-	0.4	-.-
P2O5	-.-	-.-	-.-
MnO	-.-	-.-	-.-
ClO	-.-	-.-	-.-
SO3	-.-	-.-	45.0
OXYGEN	3.7	6.2	-.-
TOTAL	100.0	100.0	96.3
SI	10.31	5.81	
AL	4.56	5.25	
FE	-.-	0.23	
MG	-.-	0.21	
CA	0.98	-.-	
NA	2.34	0.10	
K	0.03	1.80	
TI	-.-	0.04	
P	-.-	-.-	
MN	-.-	-.-	
CL	-.-	-.-	
S	-.-	-.-	
O	32.0	24.0	
	Ab 69.7		
	An 29.4		
	Or .9		
NAME	Oligoclase	Muscovite	Pyrrhotite

more recent is finer-grained (to .1mm), subhedral, green and pleochroic.

Fine-grained (to .37mm), brown, anhedral, pleochroic biotite occurs in segregated masses and may represent altered, xenolithic fragments. Microcline is found as fine-grained (to .1mm), gridiron-twinned, crystals within the groundmass and also as the previously mentioned patches within the oligoclase porphyroblasts. The predominant opaque is pyrrhotite (Table 35). Zircon, carbonate and chlorite are occasionally present within this unit.

This unit is very homogeneous chemically (Table 36); the normative rock name is consistently dacite and the SiO_2 content always between 68.5 and 71.3%. Interesting minor element abundances are: Au (up to 71 ppb), Y (less than or equal to 10ppm), Pb (greater than 21ppm), Ag (greater than 5ppm) and Sb (less than .5ppm). These rocks are consistently quartz and corundum normative with a very low normative color index (less than 7.5).

The rocks are very similar on the AFM and YTC diagram (Figure 26) with very little scatter and a highly calc-alkaline affinity. They do show a somewhat scattered pattern on the Streckeisen diagram (Figure 27) but are similar in that both have less than 8% alkali feldspar and less than 27% quartz. The composition can range from a diorite through a quartz diorite to a tonalite.

TABLE 36

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Brown Showing Intrusive Unit 22 and Quartz Vein

UNIT	22a	22a	22b	22b	QUARTZ V
SAMPLE	196	200	176	198	181
SiO2	69.10	71.31	54.81	61.47	95.98
Al2O3	16.97	15.59	14.60	18.12	1.70
Fe2O3	0.79	0.94	2.90	1.40	0.09
FeO	1.75	1.73	11.64	4.53	0.78
CaO	2.19	2.51	6.22	4.14	0.28
MgO	1.04	1.10	4.12	2.69	0.06
Na2O	5.12	3.87	3.54	4.25	0.76
K2O	2.45	2.36	0.46	2.38	0.26
TiO2	0.42	0.43	1.36	0.74	0.08
P2O5	0.13	0.12	0.14	0.18	0.01
MnO	0.04	0.04	0.21	0.10	0.01
Cu	16.0	16.0	120.	62.0	190.
Ag	.5	<.5	<.5	1.0	gt 10.0
Au	<2.	5.	9.	7.	7200.
Zn	51.0	56.0	28.0	76.0	3200.
Y	0.	0.	30.	10.	0.
Pb	21.	64.	<2.	14.	gt 4000.
Zr	120.	100.	60.	120.	20.
As	6.	5.	5.	2.	9.
Sb	.5	.3	.6	.2	16.0
V	45.	44.	430.	130.	14.
Cr	44.	55.	38.	62	116.
Mo	4.0	°.5	3.0	2.0	3.
Co	7.0	5.0	10.0	20.0	1.0
Ni	8.0	4.0	2.0	21.0	3.0
QZ	23.20	32.27	7.17	12.45	89.53
CO	2.23	2.40	-.-	1.44	-.-
OR	14.46	13.97	2.73	14.06	1.52
AB	43.33	32.76	29.93	35.98	6.43
AN	9.99	11.63	22.60	19.39	0.46
DI	-.-	-.-	6.17	-.-	0.74
HY	4.52	4.52	24.28	12.82	1.00
MT	1.15	1.36	4.20	2.03	0.13
IL	0.80	0.81	2.58	1.41	0.15
AP	0.32	0.29	0.34	0.41	0.03
CI	6.47	6.69	37.23	16.26	2.02

gt = greater than

Figure 26: AFM and YTC diagrams for Brown showing intrusive rocks (unit 22). A = Na_2O + K_2O, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1962).

○ Quartz plagioclase porphyry (subunit 22a)

● Quartz diorite (subunit 22b)

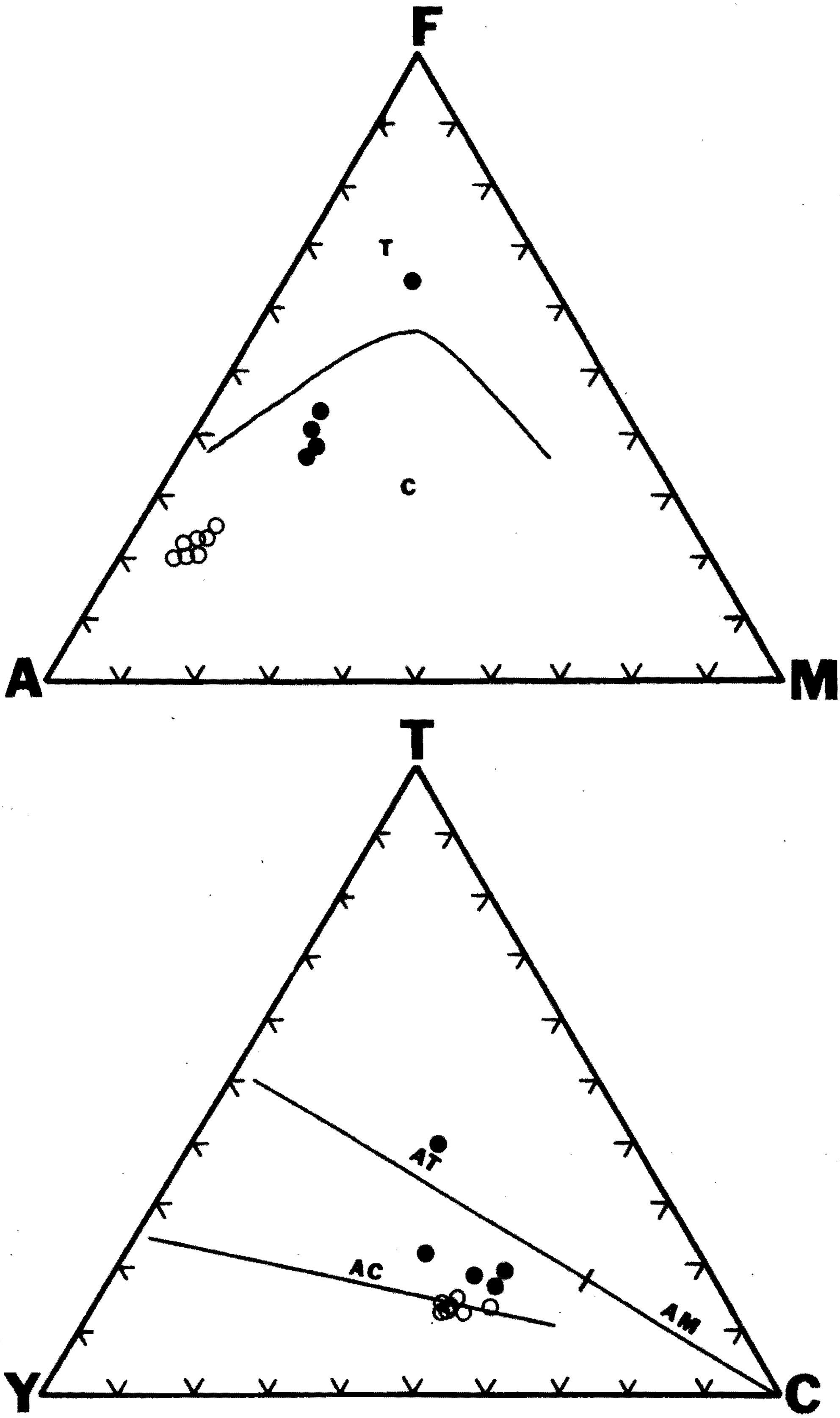
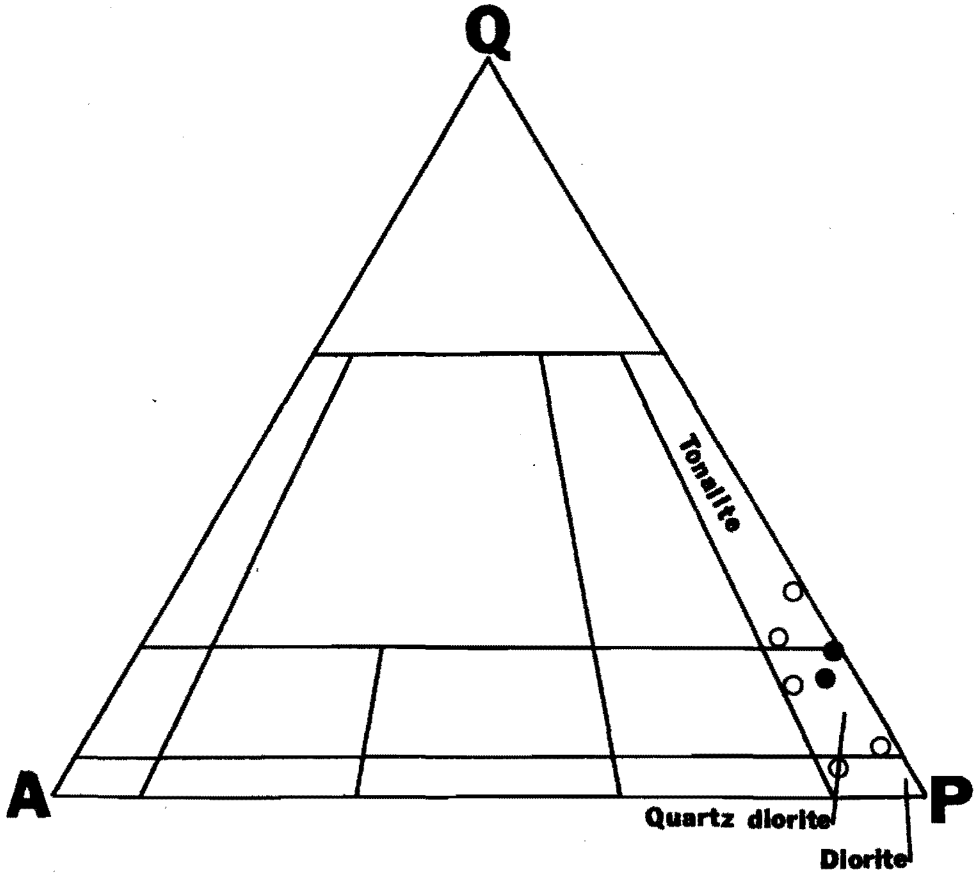

F
T
C
A
M
T
AT
AC
AM
Y
C

Figure 27: Streckeisen classification for Brown showing intrusive samples. Q = quartz, A = alkali feldspars, P = plagioclase, all given in modal percentages and normalized such that Q + A + P = 100% (Streckeisen, 1973).

○ Quartz plagioclase porphyry (subunit 22a)

● Quartz diorite (subunit 22b)


Q
Tonalite
A
P
Quartz diorite
Diorite

.3 Quartz Diorite (subunit 22b)

Interpreted as the oldest of the local intrusives, this rtz diorite can be very easily misidentified as a silt- ne unit. It has a high percentage of fine-grained (to m) muscovite. Like the quartz plagioclase porphyry, re are two generations present: the older is anhedral, phyroblastic, and non-pleochroic; and the younger is en, subhedral and pleochroic. No orientation is observed either case. Fine-grained (to .3mm), anhedral quartz urs mostly as a mosaic groundmass but some fine-grained ingers also occur. Normally-zoned, rarely twinned, anhe- l plagioclase is also present in the mosaic groundmass is very hard to distinguish from the quartz. Microcline always present and is usually fine-grained, anhedral and sesses the gridiron twinning. Biotite, carbonate, zircon opaques are also present.

This unit appears to have an intrusive fabric in thin :ion. The groundmass of subunit 22a is very similar to groundmass of this unit. The presence of microcline and ence of garnet are factors in the determination of a ous origin for this unit. The absence of bedding also ributes toward an intrusive interpretation. One addi- al discriminating factor is that grading in the size of quartz grains between muscovite layers occurs in the ment-derived rock (subunit 9b) and not in the igneous- ved one (subunit 22b).

Chemically, most samples within subunit 22b are homoge-
ous, with SiO_2 between 54 and 62%. Possible economically
teresting minor element abundances are: Cu (greater than
ppm), Ag (up to 6 ppm), Au (up to 660ppb), Pb (up to 650
m), As (up to 6ppm) and V (up to 430ppm). The rocks con-
in normative quartz and usually corundum (Table 36) and
e normative name is either quartz monzodiorite or quartz
orite. Normative color index is between 15 and 37.

With one exception, these rocks appear very similar
emically when plotted on the AFM and YTC diagrams (Figure
). Sample 176 is the exception and appears tholeiitic,
ile the rest are very homogeneous and calc-alkaline.
ntamination of country rock material probably is a factor
the variable chemical composition of sample 176. Figure
shows a very distinct quartz diorite modal classification
r 22b.

The rock is commonly very sheared with quartz, plagi-
lase and opaques filling the fractures. A schistosity due
shearing is also commonly imparted and mineralized quartz
ning (described below) is very common within these areas
the unit.

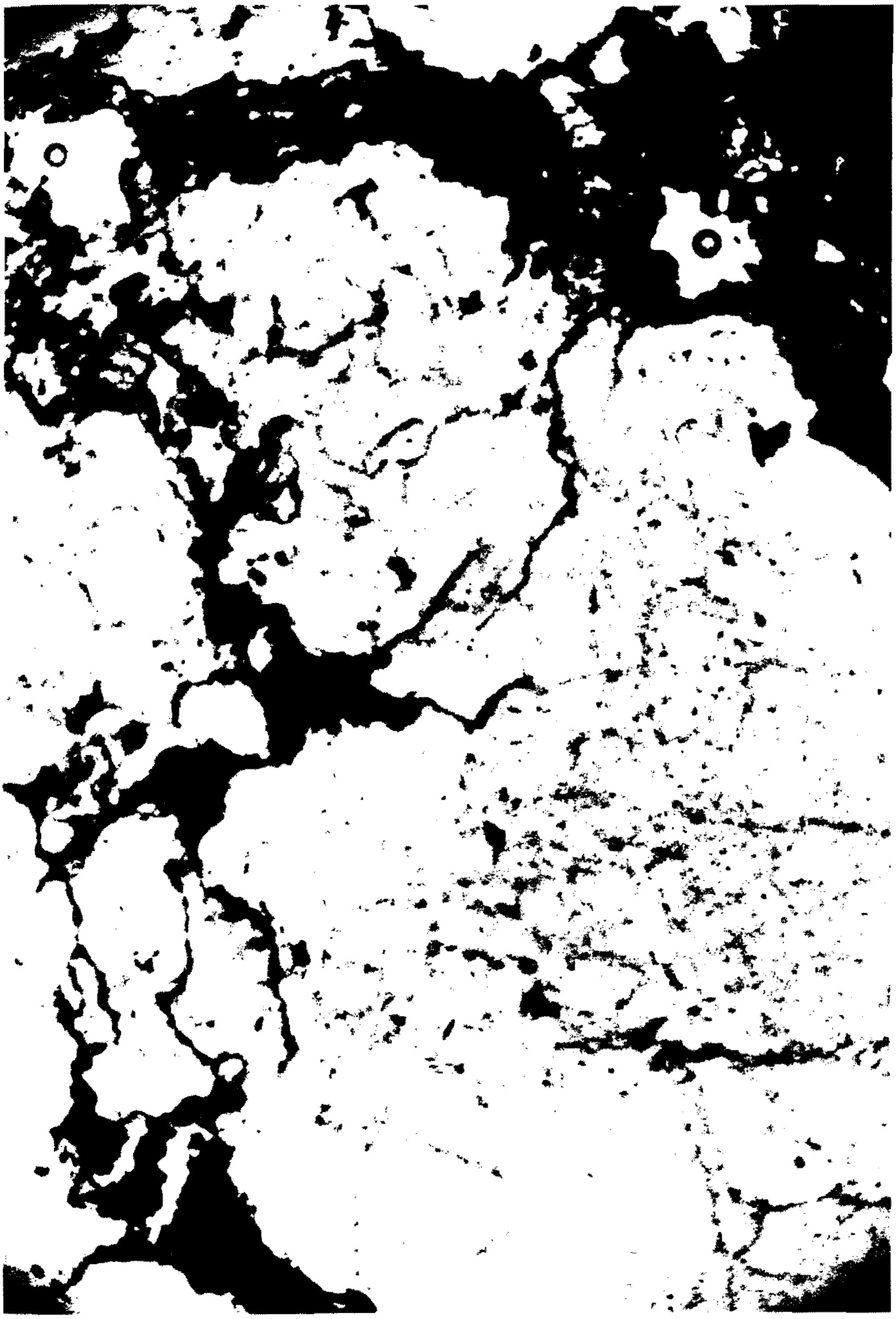
.3.1 Mineralized Quartz Veins

Mineralized quartz veins up to 5 cm wide occur within
fractured areas of subunits 22a and 22b. These frac-
ed areas follow the drag-folded trend of the surrounding
ts.

Modally, these veins contain a very high percentage of medium-grained (to 1mm), undulose, very serrate, polycrystalline quartz with very fine-grained dusty opaque inclusions. The next most abundant minerals present consist of fine- to medium-grained (to 2mm), anhedral and euhedral opaques. They occur as fracture fillings, implying later crystallization than the quartz (Figure 28). The predominant opaques are galena, pyrrhotite, pyrite and gold, all occurring separately. Muscovite and plagioclase occur as xenolithic inclusions.

Chemically, these veins naturally contain high SiO_2 contents. The most interesting chemical aspects, in terms of potentially economic deposits, involve the minor elements. Very high Cu (greater than 75ppm), Ag (greater than 0ppm), Au (up to the instrument detection maximum of 0,000ppb), Zn (up to 3200ppm), Pb (up to instrument detection maximum of 4000ppm), As (up to 22ppm), Cr (up to 80pppm), and very low Y (0), Zr (less than 20ppm), Sb (less than 16ppm), V (less than 37ppm), Mo (less than 4ppm), Co (less than 4ppm), and Ni (less than 5ppm) contents are present.

Figure 28: Photomicrograph of opaque-filled fractures in a quartz vein from the Brown showing sample 181. Note dendritic nature of opaques. Plane polarized light, 88x.



.2 CENTRAL SHOWING

The Central showing is located in the west central por-
ion of the Mirage claim. Throughout early literature
3ateman, 1945 and Milligan, 1960), this showing is referred
) as being in the C.L. group. There are six trenches, all
: which were studied.

Regionally, these trenches occur within the confines of
ie Fraser Lake-Eldon Lake sedimentary section (unit 9),
ore specifically within the greywackes (subunit 9a). On a
ocal scale (Plate III), the area contains Fraser Lake mafic
olcanic rocks 4a and 4g, Fraser Lake-Eldon Lake volcanic-
istic subunits 9a, 9b, 9bg and some post-Wasekwan intrusive
ocks (subunits 23a, 23b).

The area has a high degree of shearing but no struc-
ral features such as drag-folding seem to be present. The
earing is in the wall rocks; the intrusives are much less
eared. The intrusives appear to crosscut the country
cks at a low angle and are therefore interpreted as dikes.

2.1 Fraser Lake Mafic Volcanic Rocks (unit 4)

2.1.1 Andesite (subunit 4a)

Somewhat sheared massive andesite occurs in the south-
st portion of the map area and intersects the southern
:tion of trench #2. It occurs as an interbed within a
:nblende-bearing greywacke (subunit 9a). Within the
:nch, it appears as a medium green-grey gneissic rock with

undant medium-grained amphibole and minor plagioclase, artz, chlorite and calcite.

Modally (Table 37), this unit contains more amphiboles 2%) and a little less quartz, epidote and carbonate than e regionally occurring units. The amphibole is actinolic (Table 38) rather than the normal tschermakitic hornende. It is found as medium-grained (to .9mm), subhedral, ightly green pleochroic, and sometimes as radially fibrous ystals. The plagioclase occurs as fine-grained (.45mm), hedral to subhedral, mosaic-like and "clot-like", twinned sericitic crystals with an andesine composition n_{32}) (Table 38). Minor ilmenite, quartz, calcite and lorite are present. Highly sheared portions of the thin ction show that the amphibole-rich areas revert to muscove + plagioclase + chlorite + calcite rich areas.

Whole-rock chemical analyses show an increase in MgO, l a decrease in Fe_2O_3, FeO and TiO_2 relative to the ional subunit 4a. Minor chemistry shows some interesting nges, most notably increases in As, Cr and Ni and reases in Cu and Zn (Table 39). Normatively, the rocks not vary widely from the regional occurrences.

The AFM and YTC diagrams show marked differences from normal distribution. The local sample plots within a c-alkaline field on the AFM due to the decrease in Fe tents and in the highly magnesian basalt series of the due to the high Cr content (Figure 29). This unit nor-

TABLE 37

Point Counted Modes and Average, Visually Estimated Modes of Central Showing Volcanic and Intrusive Rocks (subunits 4a, 4g, 23a, 23b)

UNIT	4a	4g	4g	4g	23a	23a	23a	23b
SAMPLE	164	155	171	$\bar{X}$ N=3	151	153	$\bar{X}$ N=3	159
Quartz	pr.	3.4	33.8	12.7	-.-	pr.	.7	9.
Plagioclase	39.2	34.2	6.2	26.8	-.-	-.-	-.-	-.-
White Mica	3.8	6.4	4.8	8.1	13.6	4.2	9.9	.2
Chlorite	2.4	.2	.4	.2	-.-	-.-	-.-	-.-
Amphibole	52.4	9.6	46.2	24.3	-.-	-.-	-.-	-.-
Epidote	-.-	-.-	pr.	.03	-.-	-.-	-.-	-.-
Carbonate	2.2	43.2	.8	23.3	.8	.4	10.4	29.8
Opaque	pr.	3.0	1.8	2.6	3.2	4.8	4.7	6.2
Biotite	-.-	-.-	pr.	.03	-.-	-.-	-.-	-.-
Apatite	-.-	-.-	pr.	.03	pr.	-.-	.03	-.-

$\bar{X}$ - mean
pr. - present

TABLE 38

ypical Chemical Composition of Central Showing Volcanic and Intrusive Minerals

AMPLE	AMPHIBOLE	PLAG	PLAG	OPAQUE	OPAQUE
iO2	51.6	65.3	67.7	0.3	-.-
l2O3	4.3	21.1	19.1	-.-	-.-
eO	17.5	-.-	-.-	47.3	47.0
gO	13.2	-.-	-.-	-.-	0.3
aO	6.8	5.2	0.2	0.1	0.1
a2O	0.9	6.1	9.6	0.3	0.3
2O	0.1	0.0	-.-	-.-	-.-
iO2	-.-	-.-	-.-	55.8	-.-
2O5	-.-	-.-	-.-	-.-	-.-
nO	0.4	-.-	0.2	2.2	-.-
lO	-.-	0.1	-.-	-.-	-.-
O3	-.-	-.-	-.-	-.-	52.2
XYGEN	5.3	2.2	3.4	-.-	-.-
OTAL	100.0	100.0	100.0	105.8	100.0
I	7.13	11.14	11.32	0.01	
L	0.70	4.24	3.76	-.-	
E	2.02	-.-	-.-	1.88	
G	2.72	-.-	-.-	-.-	
A	1.00	0.95	0.04	0.00	
A	0.23	2.02	3.10	0.02	
	0.01	0.01	-.-	-.-	
I	-.-	-.-	-.-	1.99	
	-.-	-.-	-.-	-.-	
N	0.05	-.-	0.03	0.09	
L	-.-	0.03	-.-	-.-	
	-.-	-.-	-.-	-.-	
	24.0	32.0	32.0	6.0	
R=	56.8	Ab 67.8 An 31.9 Or .3	Ab 98.8 An 1.2		
AME	Actinolite	Andesine	Albite	Ilmenite	Pyrrhotite

R - amphibole ratio

TABLE 39

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Central Showing Volcanic and Intrusive Rocks (subunits 4a, 4g, 23a, 23b)

UNIT	4a	4g	4g	23a	23a	23b
SAMPLE	164	157	171	156	158	159
SiO2	55.13	50.67	53.60	68.77	51.03	55.87
Al2O3	14.61	13.21	14.74	17.35	13.04	10.04
Fe2O3	1.73	1.94	2.91	1.82	2.37	2.45
FeO	5.80	7.51	10.93	1.03	7.09	7.98
CaO	8.96	9.69	7.44	0.74	9.98	12.04
MgO	8.79	7.95	3.95	0.62	7.39	5.40
Na2O	3.75	4.77	3.66	8.21	4.91	4.80
K2O	0.40	2.19	0.68	1.01	2.16	0.16
TiO2	0.49	1.29	1.53	0.28	1.27	0.70
P2O5	0.17	0.60	0.35	0.15	0.54	0.33
MnO	0.17	0.19	0.23	0.03	0.22	0.21
Cu	5.0	52.0	75.0	24.0	74.0	8.0
Ag	<.5	1.0	<.5	2.0	1.5	1.0
Au	2.	26.	6.	460.	150.	6100.
Zn	18.0	88.0	47.0	96.0	120.	60.0
Y	0.	10.	20.	0.	10.	20.
Pb	6.	31.	6.	120.	35.	55.
Zr	50.	80.	90.	450.	90.	50.
As	9.	7.	4.	10.	8.	120.
Sb	.7	4.0	.5	2.3	1.2	13.0
V	140.	220.	410.	30.	220.	120.
Cr	346.	188.	27.	31.	185.	137.
Mo	6.0	8.0	6.0	11.0	9.0	21.0
Co	9.0	38.0	15.0	<.5	35.0	28.0
Ni	47.0	74.0	5.0	<.5	70.0	69.0
QZ	0.60	-.-	4.55	15.09	-.-	0.25
CO	-.-	-.-	-.-	1.77	-.-	-.-
OR	2.39	12.92	4.02	5.95	12.78	0.97
AB	31.74	20.88	30.96	69.48	21.64	40.65
AN	21.84	8.17	21.78	2.66	7.17	5.35
NE	-.-	10.56	-.-	-.-	10.78	-.-
DI	17.34	29.16	10.80	-.-	31.44	43.04
HY	22.27	-.-	19.97	1.53	-.-	4.09
OL	-.-	11.67	-.-	-.-	9.10	-.-
MT	2.51	2.81	4.21	2.61	3.43	3.56
HM	-.-	-.-	-.-	0.02	-.-	-.-
IL	0.93	2.44	2.90	0.53	2.41	1.33
AP	0.39	1.43	0.83	0.36	1.27	0.78
CI	43.05	46.08	37.87	4.69	46.39	52.02

ly plots in the tholeiitic field of the AFM diagram and
Archean tholeiitic field of the YTC diagram (Figure 11).

.1.2 Intermediate Tuff (subunit 4g)

A highly sheared, intermediate tuff is found in the tern portion of the map area and intersects the southern tion of trench #5 and the northern portion of trench #6. occupies a position between hornblende-bearing greywackes bunit 9a). Within the trenches, it appears medium to k grey, schistose when highly sheared and gneissic when , with fine-grained visible hornblende, biotite and rtz. The outcrop is somewhat magnetic and contains abun- t calcite and albite veins when sheared.

Modally, the rocks of these local occurrences differ m those of the regional occurrences by containing more rtz, plagioclase, muscovite and carbonate with less hibole and opaques. The plagioclase is fine-grained (to mm), subhedral to anhedral and is found as "clots", in ns and as a mosaic groundmass. The "original" grains e an andesine composition and the plagioclase in the ns is albite. Most grains are untwinned and normally- ed. The amphibole is a medium-grained (to 2.2mm), anhe- l to subhedral, fibrous, porphyroblastic, actinolite. cite and chlorite alteration is very common. The quartz ur as part of the fine-grained groundmass.

Many of the rocks exhibit late-stage brecciation due to shearing. Some of the amphiboles appear broken off with the breccia fragments. A highly cataclastic mylonite occurs at the south end of trench #5. Higher amounts of muscovite, chlorite, calcite and albite occur in these rocks.

Whole-rock chemistry shows higher FeO, CaO, K_2O, and P_2O_5 with decreased Fe_2O_3 compared to the regional 4g subunit, as well as increased Au, Pb, As, Sb, Cr, Mo and Ni and decreased Y, Zr and V. There is little normative difference between these local occurrences and the regional occurrences.

The AFM and YTC diagrams also are similar in appearance to those of the regional samples with one exception. The exception is sample 157 which plots in the calc-alkaline field of the YTC diagram. The differences are probably due to a high degree of albitite contamination; these samples plot very near the albitite area (Figure 29).

4.2.1.3 Fraser Lake-Eldon Lake Volcaniclastic Rocks (unit 9)

The majority of samples occurring within the Central Showing are volcaniclastic rocks which is to be expected as the showing is within an area dominated by volcaniclastic rocks. Eleven of eighteen volcaniclastic occurrences are hornblende-bearing greywacke (subunit 9a); the seven remaining are siltstone (subunit 9b). A garnet-bearing siltstone (subunit 9bg) is present as well.

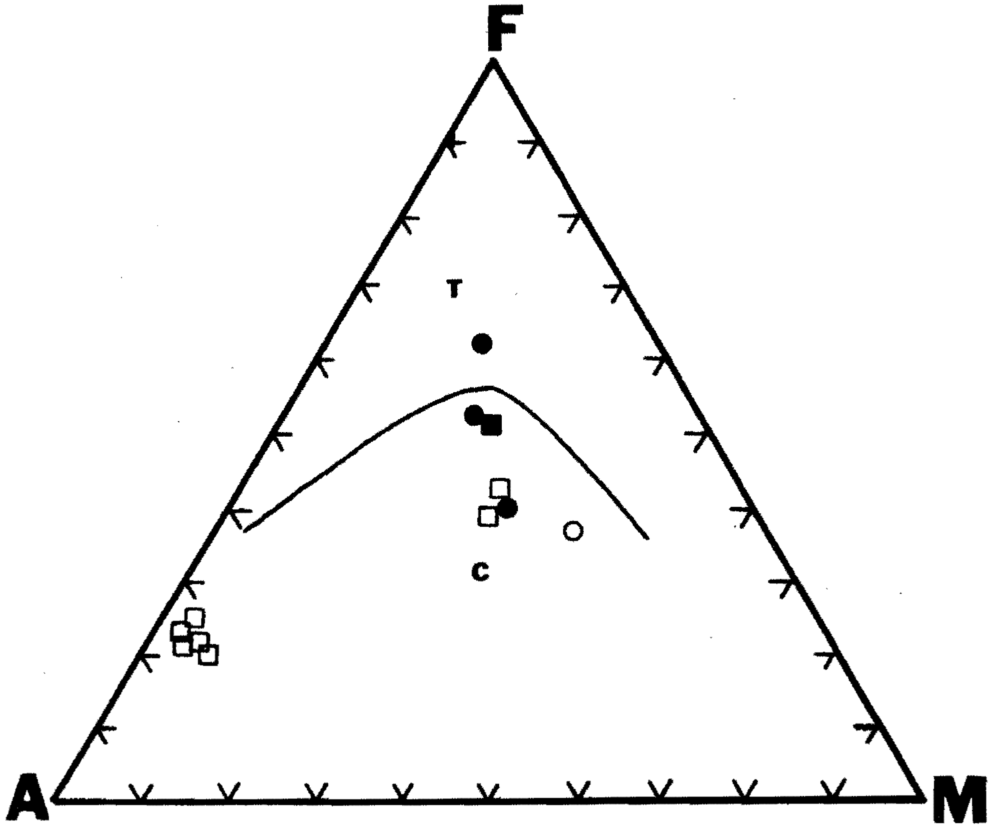
Figure 29: AFM and YTC diagrams for Central showing units 4 and 23. A = Na_2O + K_2O, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1962).

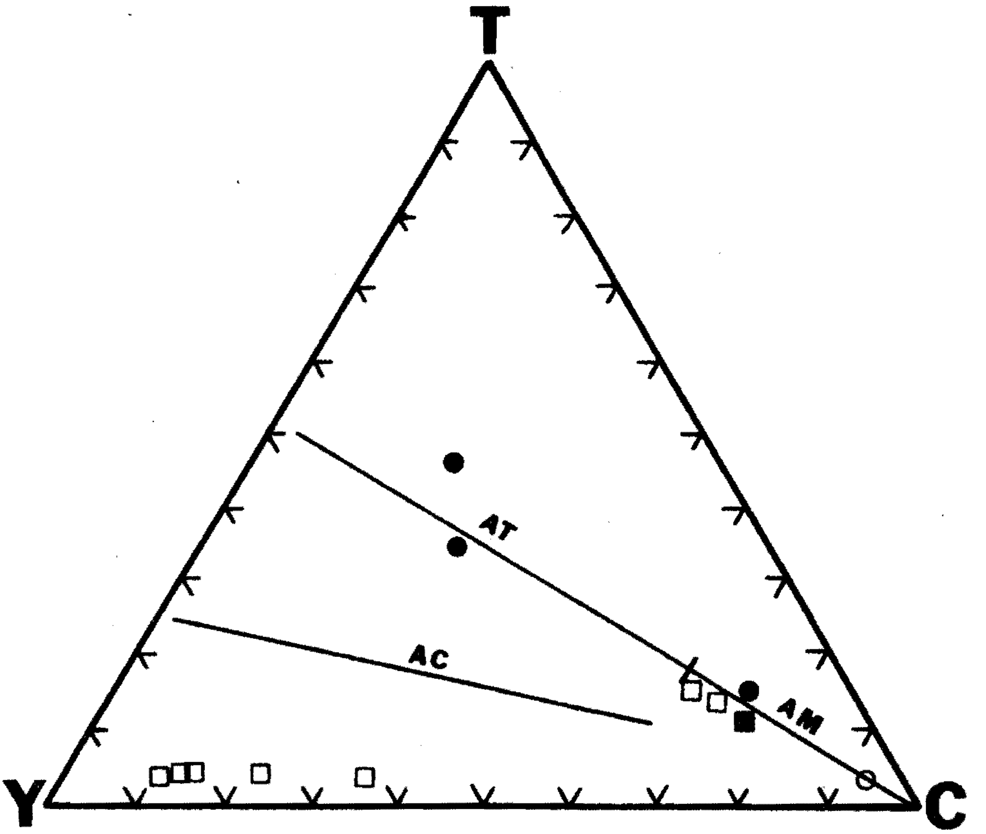
○ Fraser Lake andesite (subunit 4a)

● Fraser Lake intermediate tuff (subunit 4g)

□ Albitite (subunit 23a)

■ Alkali-feldspar quartz syenite (subunit 23b)


F
T
C
A
M


T
AT
AC
AM
Y
C

4.2.1.4 Hornblende-bearing Greywacke (subunit 9a)

A locally sheared hornblende-bearing greywacke occurs throughout the map area. It is the dominant country rock and is in contact with all of the other units of the showing. It appears as a fine-grained, medium to dark grey, well-bedded gneiss. As shearing becomes dominant, the outcrops appear more schistose. Medium-grained amphibole and fine-grained quartz are usually the only other visible minerals.

Modally (Table 40), these local greywackes contain more plagioclase and muscovite, with less quartz, amphibole and epidote.

The dominant amphibole occurring is a medium-grained (to 4.4mm), subhedral, highly poikiloblastic, sieve-textured, light green pleochroic hornblende (Table 41). Amphiboles are aligned in two mutually perpendicular directions.

Fine-grained quartz occurs as anhedral grains in the mosaic groundmass. Individual beds of material of varying grain size are present. Fine-grained anhedral plagioclase (andesine), which exhibits rare albite twinning and sericite alteration, also occurs. Some grains appeared to be rolled and rounded by shearing and others appear "clot-like". Fine-grained ilmenite blebs are the dominant opaques. They follow a regional foliation that is nearly parallel to that of the amphiboles. Calcite, muscovite and chlorite (pennite) occur where shearing is dominant.

Point Counted Modes and Average Visually Estimated Modes of Central Showing Volcaniclastic Rocks (unit 9)

UNIT	9a	9a	9a	9b	9b	9b	9bg	9bg	9bg
SAMPLE	150	205	X N=10	173	204	X N=4	169	203	X N=3
Quartz	3.4	3.2	26.2	12.6	67.0	36.4	56.4	65.6	56.3
Plagioclase	30.4	27.4	18.8	14.6	.4	6.2	9.6	1.2	5.4
White Mica	-.-	.2	12.4	18.4	30.8	34.8	17.4	22.8	20.7
Chlorite	3.2	5.2	5.3	-.-	-.-	-.-	4.2	.6	1.6
Amphibole	58.8	56.4	28.8	41.8	-.-	14.5	7.4	2.4	4.9
Epidote	-.-	-.-	.3	pr.	-.-	.3	pr.	pr.	.1
Carbonate	1.0	3.2	2.8	12.4	1.4	7.2	4.2	-.-	1.4
Opaque	3.2	3.8	2.5	.2	.4	.7	.8	.4	.7
Garnet	-.-	-.-	-.-	-.-	-.-	-.-	pr.	3.6	1.9
Biotite	-.-	-.-	-.-	-.-	-.-	-.-	pr.	3.4	3.8

X - mean
pr. - present

TABLE 41

Typical Chemical Composition of Central Showing Unit 9 Minerals

MPLE	AMPH	AMPH	PLAG	GARNET	EPIDOTE	OPAQUE
O2	47.4	39.9	59.9	37.2	37.8	2.5
2O3	19.1	18.1	24.0	20.6	23.7	0.1
O	18.7	23.0	-.-	31.4	11.8	76.9
O	8.7	3.4	0.1	0.9	0.1	-.-
O	11.9	11.3	6.4	5.9	23.9	0.2
2O	1.3	1.1	6.6	0.3	-.-	-.-
O	0.2	0.5	0.1	-.-	-.-	-.-
O2	0.5	0.4	-.-	0.2	-.-	-.-
O5	-.-	-.-	-.-	-.-	-.-	-.-
O	0.4	0.3	0.1	7.2	-.-	0.2
O	-.-	0.1	-.-	-.-	-.-	-.-
3	-.-	-.-	-.-	-.-	-.-	1.3
YGEN	1.8	1.9	2.8	-.-	2.8	18.7
TAL	100.0	100.0	100.0	103.8	100.0	100.0
	7.04	6.06	10.29	5.90	3.00	0.56
	1.50	3.25	4.86	3.85	2.72	0.03
	2.33	2.92	-.-	4.17	0.78	14.37
	1.93	0.76	0.04	0.21	0.01	-.-
	1.90	1.84	1.17	1.00	2.04	0.04
	0.37	0.34	2.21	0.08	-.-	-.-
	0.04	0.10	0.02	-.-	-.-	-.-
	0.06	0.05	-.-	0.03	-.-	-.-
	-.-	-.-	-.-	-.-	-.-	-.-
	0.05	0.04	0.02	0.97	-.-	0.04
	-.-	0.02	-.-	-.-	-.-	-.-
	-.-	-.-	-.-	-.-	-.-	0.23
	24.0	24.0	32.0	24.0	13.0	32.0
			Ab 64.9			
			An 34.4			
=	44.7	20.5	Or .7			
ME	Hornblende	Ferro-hastingsite	Andesine	Almandine	Epidote	Magnetite

- amphibole ratio

Major differences in chemistry from that of the regional greywackes are increases in the major oxides FeO and K_2O, and decreases in CaO. SiO_2 is commonly greater than 54% in these rocks. Minor element differences are increases in Au, Zn, Sb, Cr, Mo and Co; no notable decreases occur (Table 40). Normatively, the local occurrences are not much different from those of the surrounding area (Table 40).

The YTC diagrams for the two types of occurrences are practically the same. The AFM diagrams vary somewhat in that many of the local greywackes appear to have slight calc-alkaline affinities (Figure 30); local metasomatic effects may account for this difference.

4.2.1.5 Muscovite-bearing Siltstone (subunit 9b)

A locally sheared muscovite-bearing siltstone is located in the center of the map area. It intersects the northern portion of trench #4 and is surrounded by hornblende-bearing greywacke.

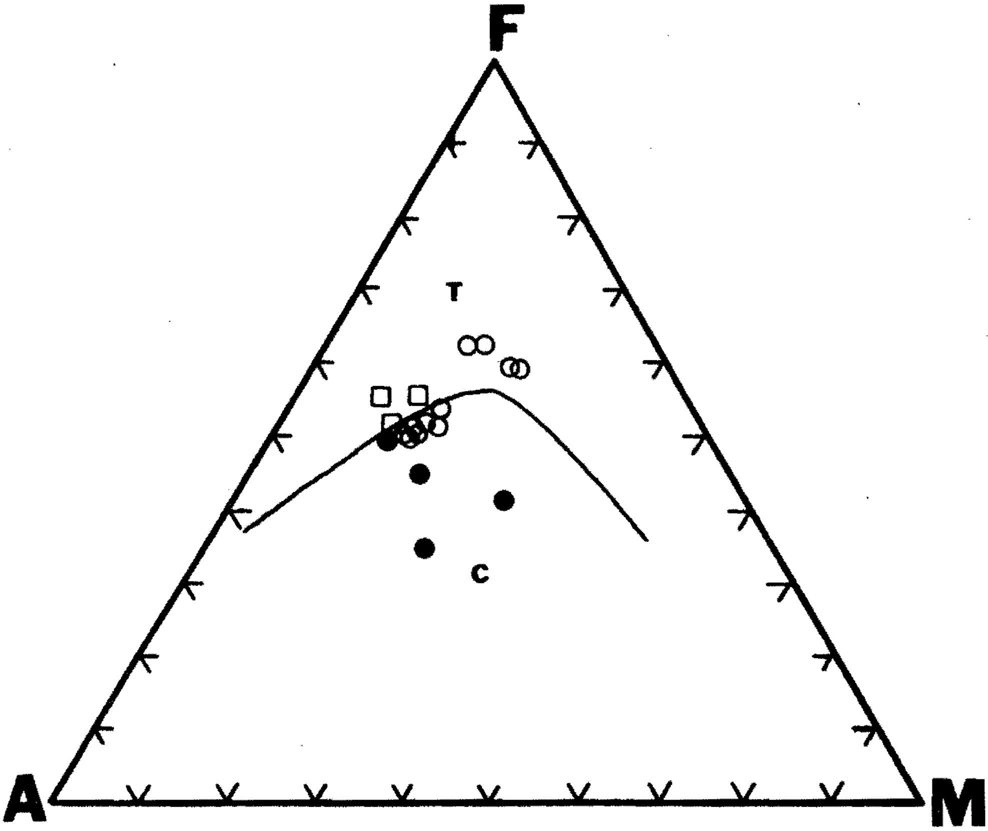
On outcrop, it appears as a dark-grey or tan, aphanitic, gneissic or schistose unit, depending on the amount of shearing present. It has a very siliceous appearence even though individual quartz grains cannot be seen. Modally, the local occurrences generally contain more plagioclase, muscovite, amphibole and carbonates while having less quartz, chlorite, epidote and biotite (Table 40).

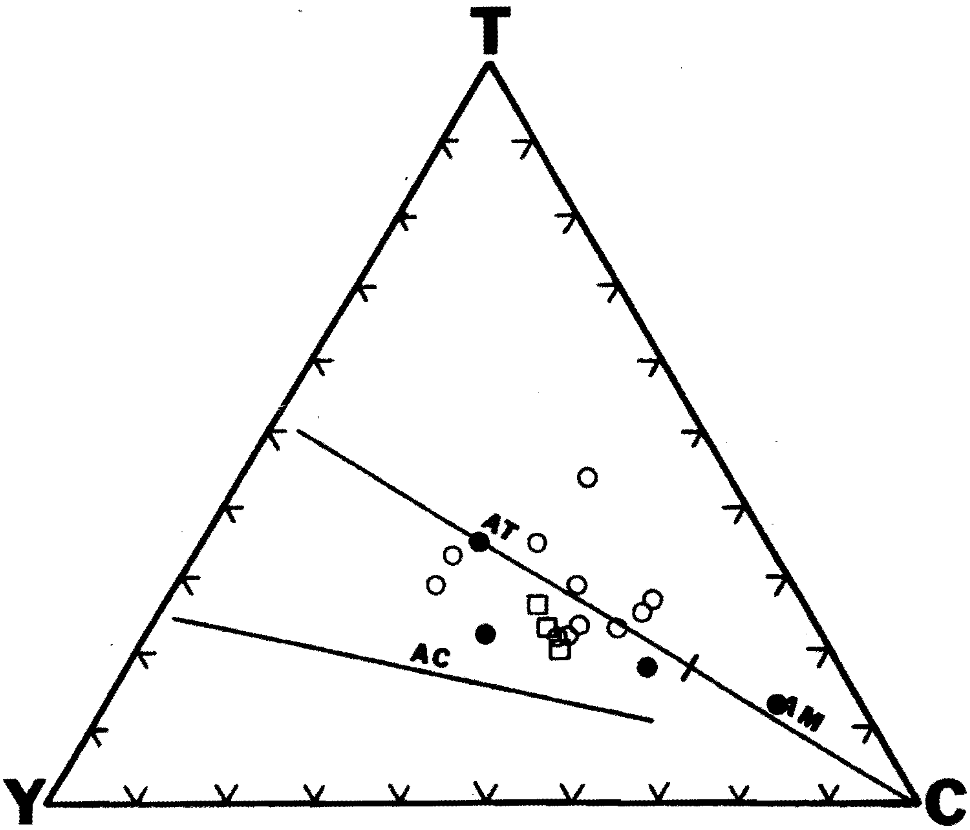
Figure 30: AFM and YTC diagrams for Central showing volcaniclastic rocks (unit 9). A = $Na_2O + K_2O$, F = FeO + 0.8998(Fe_2O_3), M = MgO, all expressed in weight percent. Y = Y + Zr (ppm), T = TiO_2 (wt.%), and C = Cr (ppm). The AFM diagram is divided into tholeiitic (T) and calc-alkaline (C) fields after Irvine and Barager (1971) and the YTC diagram has Archean tholeiitic (AT), Archean magnesian (AM) and Archean calc-alkaline (AC) basalt trends delimited after Davies et al. (1962).

○ Hornblende-bearing greywacke (subunit 9a)

● Muscovite-bearing siltstone (subunit 9b)

□ Garnet and mica-bearing siltstone (subunit 9bg)


F
T
C
A
M


T
AT
AC
AM
Y
C

Hornblende occurs as fine-grained (to .14mm), euhedral, green pleochroic grains (Table 41). A mosaic of quartz and plagioclase which are generally fine-grained, anhedral, and appear very similar, occur as the groundmass. The muscovite is fine-grained (to .1mm), subhedral, highly oriented and pleochroic. Ilmenite is the most common opaque, with some minor pyrrhotite also present. Sheared portions of the siltstone contain much muscovite and carbonate.

Chemical analyses show slightly higher Al_2O_3 and lower Fe_2O_3 than the regional units. Minor elemental analyses shows higher Cu, Ag, Au, Sb, Pb, Cr and Ni and a decrease in Zn and Co (Table 42).

Normatively, these rocks appear similar to those of regional occurrence but have a slightly lower normative color index (Table 42).

Using the AFM diagram as a criterion, the unit appears similar to the regional occurrences. The local occurrences appear slightly more tholeiitic than normal when comparing the YTC diagrams (Figure 29 versus 17).

.2.1.6 Garnet and Mica-bearing Siltstone (subunit 9bg)

Two occurrences of sheared garnet and mica-bearing siltstone are found within the Central showing. The most widespread occurs in the extreme northwest portion of the map area and has its southern contact with the hornblende-bearing greywacke. The second occurrence is a small

TABLE 42

Normalized Chemical Analysis, CIPW Normative Mineralogy and Normative Color Index of Central Showing Volcaniclastic Rocks (unit 9)

UNIT	9a	9a	9b	9b	9bg	9bg
SAMPLE	152	167	173	175B	169	203
SiO2	52.95	61.42	51.25	54.37	61.28	63.68
Al2O3	14.86	16.49	17.05	19.87	16.99	16.10
Fe2O3	2.81	1.65	1.93	1.95	1.28	1.47
FeO	11.41	7.32	6.57	6.18	7.29	7.28
CaO	7.05	4.08	10.40	5.34	4.21	3.64
MgO	4.00	2.63	6.05	3.65	2.22	1.68
Na2O	3.51	3.36	4.15	4.30	3.43	2.78
K2O	1.28	2.03	1.51	2.95	2.24	2.43
TiO2	1.58	0.78	0.69	0.93	0.79	0.40
P2O5	0.36	0.13	0.21	0.37	0.15	0.13
MnO	0.21	0.11	0.19	0.09	0.13	0.11
Cu	58.0	48.0	1.0	350.	120.	50.0
Ag	.5	<.5	<.5	1.0	.5	<.5
Au	26.	<2.	9.	23.	12.	13.
Zn	96.0	86.0	43.0	72.0	74.0	85.0
Y	30.	10.	0.	40.	20.	10.
Pb	8.	2.	10.	4.	<2.	<2.
Zr	100.	90.	50.	90.	70.	80.
As	8.	4.	4.	3.	6.	3.
Sb	.4	.6	1.4	1.0	.4	.2
V	470.	160.	210.	130.	140.	100.
Cr	21.	44.	113.	34.	41.	41.
Mo	6.0	4.0	8.0	5.0	3.0	<.5
Co	27.0	14.0	17.0	20.0	14.0	10.0
Ni	5.0	<.5	36.0	6.0	<.5	<.5
QZ	2.64	16.81	-.-	-.-	15.71	23.71
CO	-.-	1.66	-.-	0.77	1.62	2.60
OR	7.54	12.00	8.95	17.41	13.24	14.36
AB	29.66	28.43	25.97	36.42	29.01	23.51
AN	21.04	19.37	23.41	24.09	19.93	17.19
NE	-.-	-.-	4.96	-.-	-.-	-.-
DI	9.78	-.-	21.85	-.-	-.-	-.-
HY	21.43	17.54	-.-	11.42	16.79	15.41
OL	-.-	-.-	10.26	4.44	-.-	-.-
MT	4.08	2.39	2.79	2.82	1.86	2.13
IL	3.00	1.49	1.31	1.76	1.50	1.32
AP	0.84	0.32	0.50	0.88	0.35	0.32
CI	38.29	21.41	40.61	20.44	20.15	18.86

erbed within a hornblende-bearing greywacke near the cen- of the map area, just east of trench #3. On outcrop, y appear to have gneissic foliation or are schistose, ending on the amount of shearing present. They are istinguishable from the mica-bearing siltstone (subunit in hand sample.

Modally, these rocks are very similar to subunit 9b ept that they contain slightly more quartz, muscovite, orite, biotite and garnet and less plagioclase and amphi- e (Table 40). The minerals appear much the same with rohastingsite the dominant amphibole and andesine (An_{40}) dominant plagioclase (Table 41). The opaques are ilmen- and magnetite.

The major distinguishing feature of 9bg is the presence medium-grained (to 2.5mm), anhedral, highly porphyroblas- , fractured garnet which has an almandine composition ble 41).

Chemically, these rocks contain higher SiO_2 and FeO, ents with lower CaO, MgO, Na_2O, and P_2O_5. Higher Zn, As lower Pb, Sb, V, Cr, Mo, Co and Ni concentrations are associated with 9bg (Table 42).

Slight normative differences are apparent with norma- quartz and corundum always present and a slightly lower ative color index occurring (Table 42).

2 Metasomatically Derived Intrusive Rocks (unit 23)

Two petrologically and chemically distinct intrusive types occur within the map area and appear to crosscut volcanic and volcaniclastic units. It appears that two usive events occurred, in which fine-grained albitite unit 23a) was emplaced first, with a subsequent more tz-rich intrusion (subunit 23b) later emplaced into a tant sheared zone within this albitite. This relation- is verified petrologically with the alkali-feldspar tz syenite (subunit 23b) being intruded into a more tite-rich matrix that is slightly more altered and rmed.

2.1 Albitite (subunit 23a)

Interpreted as the oldest of the intrusive units, the tite appears relatively fresh except where it is in con- with subunit 23b.

On outcrop, this unit has a dark brown iron staining ure 31). On fresh surface, the sample is white to light massive, sucrosic, aphanitic, and slightly sheared.

Modally (Table 37), the rock contains a very high per- ge (mean=74.33) of fine-grained (to .35mm), anhedral, oclase (Figure 32). These grains are bent and frac- , indicating that the dike was probably intruded as a alline mush accompanied by shearing. Pericline, albite arlsbad twinning are common with normal and reverse

Figure 31: Central showing trench exposure of albitite dike. View is facing the west wall of trench #5 (Plate III).

zoning and overgrowths prevalent. The plagioclase composition determined by the Michel-Levy optical method is An_8. Microprobe analysis gives a less anorthitic content of An_2 (Table 38). Quartz occurs as fine-grained interstitial grains and vein fillings.

Fine-grained, anhedral pyrite and pyrrhotite with some galena make up the majority of the opaque population. Many of the opaques appear to have partialy dissolved and been reprecipitated as rims on the albite grains (Figure 33). Some finely dendritic opaques are also present. Fine-grained muscovite and hematite occur near sheared and fractured areas of the unit.

Chemically, this unit contains between 60 and 75% SiO_2. Many country rock xenoliths are found within the dike. The analysis of albitite containing xenoliths shows a high variability. Minor element abundances include high Ag, Au, Zn, Pb, Zr, As, Sb and Mo with low Y, V, and Cr (Table 39). The high Au and Ag contents associated with this unit make it a possible economic target.

Normatively, these rocks are highly variable with normative quartz or olivine present and nepheline, corundum and hematite sometimes present. The normative color index is also variable. It was found that samples that do not contain xenoliths have a normative color index between 4 and 6 and contaminated, xenolithic-rich rocks between 40 and 50.

Figure 32: Photomicrograph of albitite sample 153. Note anhedral poorly twinned and sericitized albite grains. Crossed polars, 378x.

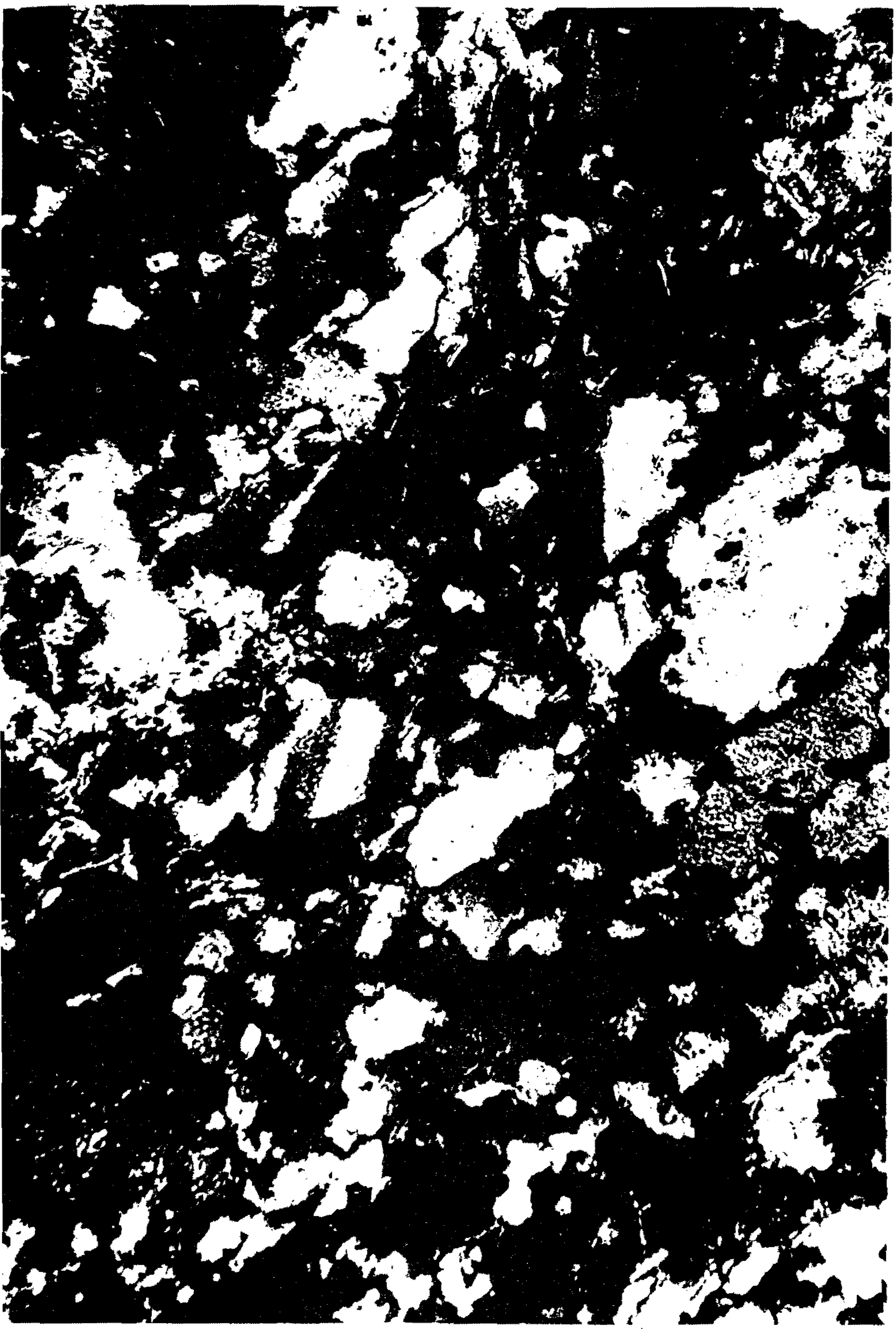
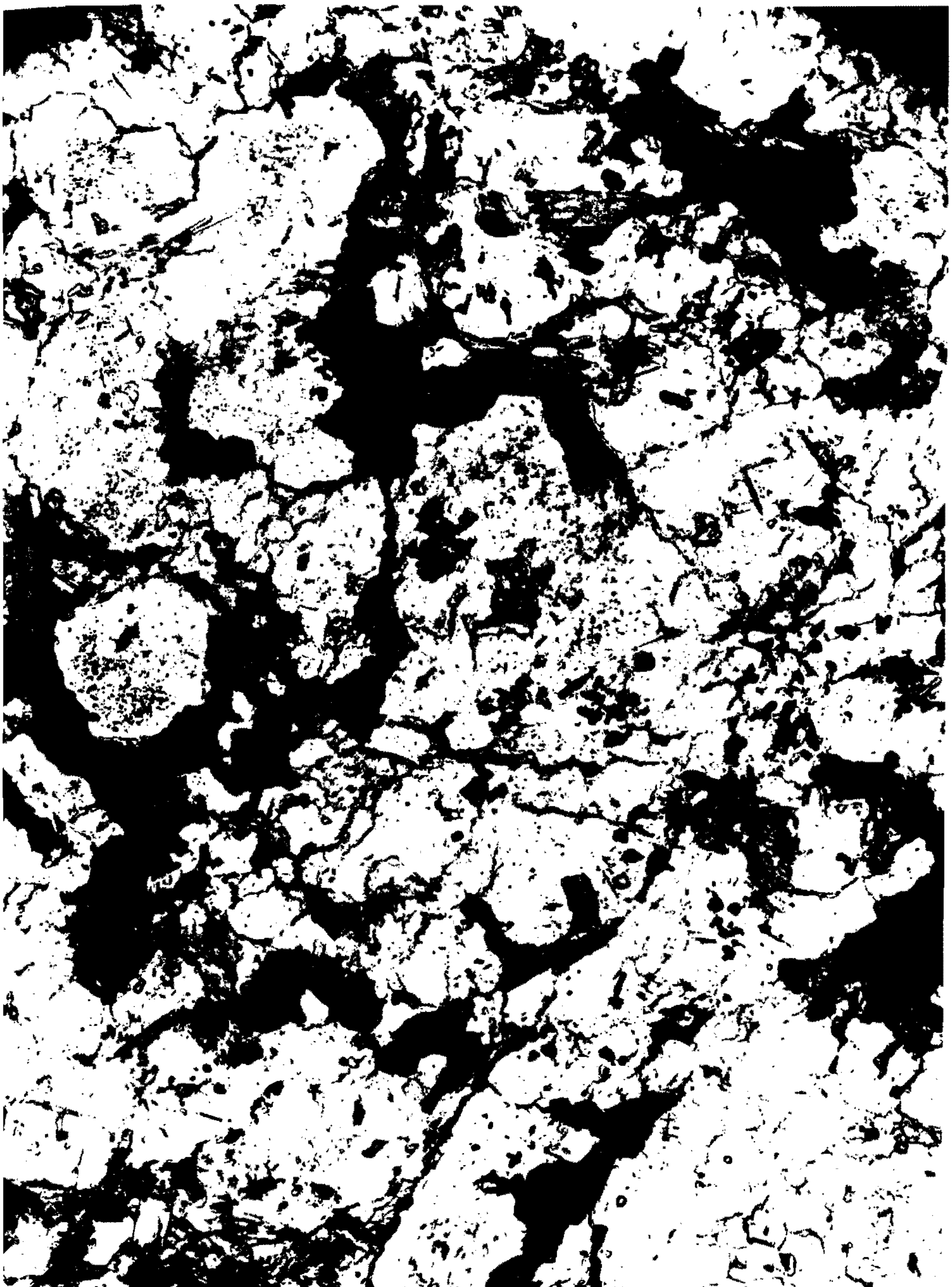


Figure 33: Photomicrograph of opaques in albitite dike from sample 153. Note embaying characteristics of opaques and their partial rimming of the slightly sericitized albite grains (top center). Plane polarized light, 233x.



The AFM and YTC diagrams (Figure 29) show a strongly calc-alkaline character for samples with no xenoliths and a much more tholeiitic character for the xenolithic ones. All samples fall within the alkali-feldspar syenite region of the Streckeisen classification scheme (Figure &cc3), but the term albitite as proposed by Bateman in 1945 is a much more descriptive term and will be adhered to in this study. Also, though this unit was obviously emplaced by a intrusive event, this does not imply an intrusive source in the classical sense. Rather, the material for this rock was derived from metasomatic processes with the surrounding rocks.

4.2.2.2 Alkali-feldspar Quartz Syenite (subunit 23b)

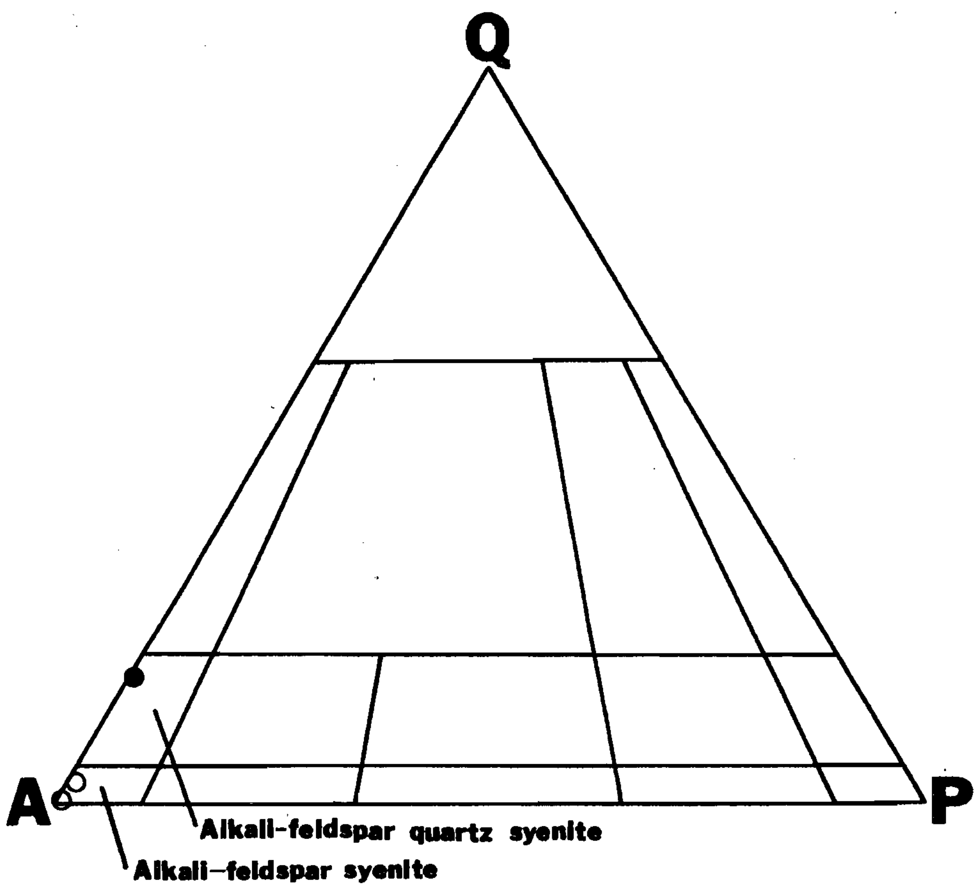
Interpreted as the youngest of the intrusive units, this syenite is also the least exposed. Only one example is found in the area; it occurred within unit 23a in trench #6. This sample falls within the alkali-feldspar quartz syenite field of Streckeisen's classification (Figure 34) and will be referred to by this nomenclature in this study.
Within the trench, the rock occurs as a light green-grey, foliated, relatively quartz-rich unit.

Modally, it contains much more quartz and less albite and muscovite than does 23a. More carbonates (calcite and siderite) and opaques (pyrite and pyrrhotite) also occur (Table 37). The albite content appears to be similar to that of the surrounding albitite unit and has a composition of An_1 as determined by the microprobe (Table 38).

Figure 34: Streckeisen classification for Central showing intrusive samples. Q = quartz, A = alkali feldspars, P = plagioclase, all given in modal percentages and normalized such that Q + A + P = 100% (Streckeisen, 1973).

○ Albitite (subunit 23a)

● Alkali-feldspar quartz syenite (subunit 23b)


Q
A
P
Alkali-feldspar quartz syenite
Alkali-feldspar syenite

Chemically, this unit is very distinct with higher Fe_2O_3, FeO and CaO and lower Al_2O_3, MgO, Na_2O and K_2O amounts than subunit 23a (Table 39). More Au, Y, As, Sb, Mo and less Ag, Zn, and Zr occur. Normative quartz and a high normative color index are associated with 23b.

The AFM and YTC diagrams show that this sample falls very close to the regions occupied by the contaminated albitite. This fact, taken in conjunction with the high normative color index and more shearing within the quartz-rich areas, indicates that this may in fact be a large xenolith of muscovite siltstone that was intruded by the albitite dike. The high Au (6100ppb) seems to contradict this interpretation, because no siltstone unit has been found to contain high Au contents. In addition, the high carbonate content (29.8%) and opaque content (6.2%) point toward an intrusive origin for this unit as no other siltstone units are mineralogically similar. One other fact supporting an intrusive origin for this unit is the modal quartz content (9%); this is low for a siltstone but fits well with a model in which the unit is emplaced after the albitite, so that both Au and Si show relative enrichment as compared to the earlier albitite dike. Material for this rock, just as the material for subunit 23a, was probably metasomatically-derived.

Chapter V

INTERPRETATION AND DISCUSSION

5.1 GEOLOGIC HISTORY

Gilbert et al. (1980) describe the deposition of the Wasekwan Lake area rocks in four main stages. The basic framework for these stages applies to the rocks in this study with only minor modifications and can be found in figure 35. The stages are:

Deposition of a volcanic platform

The lens-shaped basaltic rocks within the map area which form the base of the Wasekwan group are interpreted by Gilbert et al. (1980) as small individual shield volcanoes. The largest of these is formed by the Cockeram Lake volcanic rocks (unit 2) and is composed of aphyric, tholeiitic andesites and basalts. Among the samples collected in this study, andesites are more common than basalts. Although no pillows were found, Gilbert et al. (1980) report their occurrence. Their presence, and the occurrence of amygdales, supports the interpretation that the flows were emplaced subaqueously. The large volume of the Cockeram Lake volcanic rocks substantiates that the volcanic platform was composed predominantly of rocks derived from this source. A comparatively minor occurrence of McVeigh Lake

Figure 35: Sequence of deposition of units in the Wasekwan Lake area.

1. Extrusion of Cockeram Lake (2) and McVeigh Lake (3) volcanic rocks as seperate volcanoes on the sea floor.

2. Intercalating of the Cockeram Lake and McVeigh Lake shields to form a broad platform of volcanics.

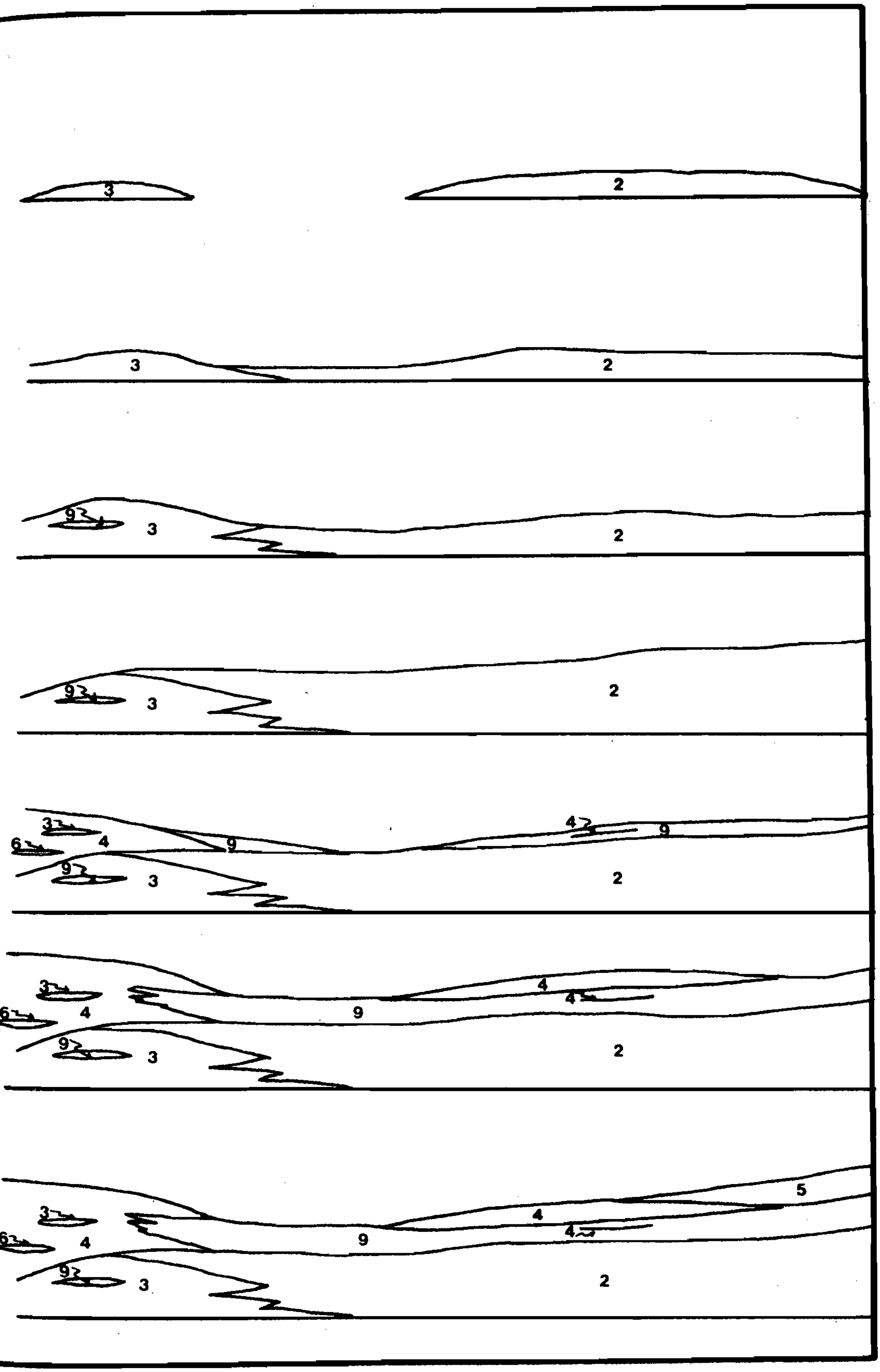
3. Continued extrusion from the two volcanic sources with minor sediment (9) influx in the west.

4. Cessation of activity at the McVeigh Lake volcanic center so that continued activity in the Cockeram Lake shield results in the overlapping of Cockeram Lake volcanic rocks onto the McVeigh Lake shield.

5. Cessation of Cockeram Lake volcanic activity with intermittent activity of McVeigh Lake volcanism, and Fraser Lake felsic volcanism (6). Major influx of Fraser Lake mafic volcanic rocks in the west and synchronous sedimentation (9) in the east and west.

6. Fraser Lake mafic to intermediate volcanism (4) becomes evident in the east.

7. Calc-alkaline volcanism of Pole Lake volcanic rocks (5) and emergence of the shield volcano from the sea.


3
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porphyritic basalts and andesites in the west represents a similar smaller shield which is contemporaneous with the Cockeram Lake basalts and andesites, as shown by the intercalation of the two units. Again, half of the samples analyzed were andesitic in composition but appear to be chemically distinct from those of the Cockeram Lake shield. They also show a tholeiitic affinity. Rare pillows, reported by Gilbert et al. (1980), point to a subaqueous volcanic environment of deposition as well.

Because of the large areal extent of the rocks, and the fact that the volcanic flows eventually covered much of the McVeigh Lake shield, the conclusion is drawn that the Cockeram Lake center was much more active during its time of deposition than was the McVeigh Lake volcanic center. It appears that sedimentation began late in the time of unit 3 volcanism with the appearance of greywackes (unit 9) near the top of the succession.

Mafic volcanism and sediment deposition

In this stage, extrusion of the Cockeram Lake basalts ceased but minor volcanism from the McVeigh Lake source (unit 3) continued. The presence of Fraser Lake felsic volcanic rocks (dacitic tuff subunit 6a) indicates volcanism in that area. The major units deposited were the Fraser Lake mafic volcanic rocks (unit 4) in the west and the beginning of synchronous sedimentation in the east (unit 9). The Fraser Lake volcanism was predominantly mafic and tholeiitic. The presence of amygdales and some sediments within this unit again supports a subaqueous depositional environment.

Intermediate and mafic volcanism and deposition of derived sediment

During this stage, the Fraser Lake (unit 4) volcanism continued with minor eruptions of McVeigh Lake volcanic rocks (unit 3) in the west. Increased sedimentation of the Fraser Lake-Eldon Lake greywackes and siltstones (subunits 9a, 9b) occurred; the sources of the sediment were local and most likely from the Cockeram Lake shield, as indicated by the very mafic and tholeiitic character of the greywackes. The interbedded siltstones may have been transported from a greater distance as indicated by their higher SiO_2 content and their predominant calc-alkaline affinity. Their source may have been the volcanic rocks of the Pole Lake area (unit 5) to the east. These rocks are calc-alkaline and were erupted late in the deposition of the Fraser Lake-Eldon Lake sedimentary rocks.

Calc-alkaline volcanism

The last phase of volcanism is recorded in the east where emplacement of Fraser Lake aphyric basalts and andesites continued, but the Pole Lake volcanic center was dominant. The rocks progress from an intermediate tuff to a dacitic tuff from west to east. Analysis shows a more calc-alkaline affinity eastward. The tuffs that comprise these units are interpreted as being emplaced in a relatively shallow, subaqueous environment by Gilbert et al. (1980). This interpretation is supported by the presence of fine bedding within the units and the occurrence of sediments (unit 9) interbedded throughout the unit. The rocks from this last stage are interpreted as being derived from a late-stage stratovolcano that developed on the upper flank of the Cockeram Lake shield (Gilbert et al., 1980). With this interpretation in mind, it is probable that the Cockeram Lake shield emerged from the surrounding seas during the time of the formation of this calc-alkaline stratovolcano. This is consistent with the observations of Ayres (1982, p. 12) who noted that the change in magma chemistry from tholeiitic basalts and andesites to calc-alkaline andesites and dacites usually coincides with this event. The fact that all of the deposits in the area appear subaqueous rather than subaerial was explained by Ayers (p. 7-17) as resulting from downslope movement of the material into the aqueous environment rather than a subaqueous eruption. This process is best visualized when considering that the development of a volcanic island requires the construction of a large subaqueous platform and that most of the subaerially erupted material is eventually deposited in the ocean. Ayers (p. 12) pointed out that if the cycle were to be completed, all of the subaerial volcanic rocks would eventually be eroded and deposited subaqueously after volcanism had ceased. This is best demonstrated by the modern-day [awaiian chain. This model appears to fit very well with ›bservations in the Wasekwan Lake area.

One further interpretation that can be made regarding :he shield volcano of the Wasekwan Lake area is its rela- :ionship to other volcanoes. It has already been estab- .ished that the McVeigh Lake volcanic rocks were formed from ı separate magma source indicating that another developing ;hield was near the Cockeram Lake shield at the time of its ormation. The distributions and types of sedimentary rocks ound in the Wasekwan Lake area were interpreted by Gilbert ·t al. (1980) to mean that the Cockeram Lake volcano devel- ›ped as an isolated volcano. The presence of some sedimen- ary rocks does establish that the shield was not the oldest olcanic unit in the belt.

All intrusive rocks were emplaced after the deposition f the Wasekwan Series with the exception of unit 1 and pos- ibly unit 13, both of which could have been emplaced during his time. Unit 1 represents local subvolcanic diabase ntrusions emplaced as sills, dikes and feeder dikes.

It is possible that unit 13 is a representative frac- ion of the underlying mafic magma chamber below the ockeram Lake shield. Comparison of AFM and YTC diagrams or the Cockeram Lake volcanic rocks (unit 2) (Figure 9) and he gabbro (unit 13) (Figure 19) show that the two are prob- bly not related. If this gabbro is contemporaneous with ny of the basalt flows then it would appear that it is part of the magma chamber for the McVeigh Lake volcanic rocks (unit 3), as they both plot in similar regions on the diagrams. It is felt that this is just coincidental, however, and that the gabbro represents a magma chamber intruded after the Wasekwan Group deposition. This is due to the fact that the gabbro exposure is found a distance from the unit 3 volcanic rocks exposures. Also, Gilbert et al. (1980) has grouped the unit 13 intrusives into the pre-Sickle group of intrusions, thereby inferring a post-Wasekwan age.

The more felsic intrusives of the area (16a,b,c) occurred after the mafic intrusion. This relationship is inferred from the spatial relationship of the two types. The mafic intrusive has an elongate exposure and occupies the center of the overturned McVeigh Lake anticline. The felsic intrusive is found in the core of the gabbro and there are no baked or altered contacts. This suggests that the lower temperature intrusion (felsic) was emplaced into the higher temperature intrusion (mafic) so that little alteration would have occurred. In addition, the felsic intrusives appear less altered then the gabbro. Thin section and chemical analyses indicates that the felsic intrusive events may have been multiple in nature, as there are slight modal and normative differences.

Unit 17 was also emplaced at this time. This, as well as the other intrusions, probably occurred after the first

formation which produced folding and faulting in an east-
rtheasterly direction. This deformation would have pro-
ced the initial zone of weakness for the Cartwright Lake
ear zone, allowing the granodiorite sill 17 to be emplaced
ong its length. The formation of an initial long zone of
akness for the emplacement of such a sill, and the pres-
ce of the sill before the main deformation event which
used the Cartwright Lake shear, are explained if the sill
s intruded at this time. The high degree of cataclasis of
e unit is also accounted for.

The second and third deformation events occurred after
e deposition of the Sickle Group. These events resulted
faulting, tilting and thrusting at the belt margins.

The fourth deformation event caused shearing and fault-
g in an east and northeasterly direction, resulting in the
rmation of the Cartwright Lake shear zone. Foliation was
veloped and regional metamorphism and anatexis also occur-
d, producing the original metamorphic fabric and grade
ilbert et al., 1980). The anatexis and concomitant intru-
ve events (e.g. Laurie Lake) could have provided material
r the sills at the Brown showing which were probably
placed at this time.

The fifth (last) deformation and intrusive event
sulted in the continued development of foliation, some at
ute angles to the original foliation, northeasterly catac-
sis and open cross-folding. The metamorphism and sur-

ıding intrusives (e.g. Burge Lake) became the driving ce for beginning the elemental activity resulting in the asomatic effects presently observed in the rocks. The ious metasomatic activities would result in the migration such elements as Si, K and Na, as well as precious met- . At this time, the development of gold-bearing quartz ns at the Brown showing, intrusion and deposition of d-rich, metasomatically derived material (albitite and ali-feldspar quartz syenite) in the subsidiary shear es of the Cartwright Lake shear (Central showing), and migration of gold to highly metasomatized areas such as tourmalinized dikes of the Rabbit's claim (1) and por- ns of the sheared granite (unit 17) took place. Final therly faulting produced the last visible change in the a. Burial with subsequent erosion has brought the pres- -day surface to view.

TECTONIC SETTING OF WASEKWAN LAKE AREA VOLCANOES

Many recent papers address the problem of the tectonic ting for Precambrian volcanic rocks of the shield areas. nions differ widely whether modern-day plate tectonic cesses were operative during Archean times, but many mod- opinions (Condie, 1981 p. 313-381) and models permit duction-plate tectonic models similar to the modern-day ogy by the end of the Archean (2.5 b.y.). Since Clark 30) has determined the rocks in the Wasekwan Lake area to hebian (terminology after Douglas, 1980), which corre- s to 1.8 to 2.5 b.y., then it should be possible to these rocks into such a tectonic framework.

Chayes (1964) has proposed a simple geochemical test he distinction of samples obtained from oceanic and noceanic environments. He suggests a very strong asso- on between petrography (geochemistry) and geography in two environments and views the TiO_2 content as the accurate discriminant. His definition of the two is as ws:

> "We describe as geographically circumoceanic any island, island chain, peninsula, or continental area lying immediately on the shoreward side, and as geographically oceanic any island lying in deep water and either isolated from or on the oceanic side of one of these troughs".

.rcumoceanic basalts are thus products of subduction- ed mechanisms and the oceanic basalts are not related ate margin tectonic processes. The test that Chayes its is from areas of Cenozoic volcanism but should also plicable to the Wasekwan Lake area if two assumptions made. They are:

Magma generation processes in the Aphebian were broadly similar to those in the Cenozoic and the chemical signatures are comparable.

Element migration during metamorphism has not obscured the relationships necessary for the test.

he first assumption appears to be valid as no highly cting arguments have been noted in the literature that egate this approach. The geochemical data from the study rea appears to correlate well with the data of Chayes 1964) and other studies comparing Precambrian volcanic ock data with that of Chayes has been done in the past Barager, 1965). The second assumption is more difficult to upport. Element migration has occurred and is indicated by uch features as quartz and calcite veining, and albitization. Weathering also may play a part in element redistribution, even though obviously weathered samples were not ollected. A judgment thus must be made as to whether the ffects of metamorphism or weathering would invalidate the ata.

In doing this, the following chemical changes +=increase and -=decrease) of ocean floor basalts must be onsidered (taken from Pearce, 1975):

eathering

very mobile :$+K_2O$,$-CaO$,$-MgO$

mobile :$-Na_2O$,$-SiO_2$

slightly mobile:$+FeO$,$+TiO_2$

immobile :AL_2O_3

reenschist facies metamorphism

very mobile :$-CaO$,$-Al_2O_3$

mobile :$+Na_2O$,$+SiO_2$,$+(MgO+FeO)$,$-K_2O$

immobile :TiO_2

The applicability of these behaviors to any plots ıvolving these elements must be considered.

The comparison of Wasekwan Lake data to that of Chayes ; presented in three different figures. Figure 36 displays ıta that corresponds to that of circumoceanic type basalts. ıta for figure 37 appear inconclusive and may fit either rcumoceanic or oceanic environments. Figure 38 shows data at appear to correspond to an oceanic environment.

The assessment begins with the TiO_2 plot of Figure 36, ıich displays the best fit of any of the data. rrespondence is almost 100% with the circumoceanic peak of ayes. Chayes considered this TiO_2 peak as an extremely curate test for determining the type of setting that the salts were emplaced and that this one plot could be used one with no need for supporting analysis. It is evident ıt TiO_2 is relatively immobile during low-grade metamor-.sm and shows an enrichment when involved in weathering ›cesses. If enrichment did occur, the result would be a e "oceanic" type analysis. Based on these facts alone, conclusion that the volcanic rocks in the Wasekwan Lake ı had a circumoceanic location related to subduction pro-;es rather than a "hot-spot" Hawaii-type oceanic origin, be made.

MgO, K_2O and CaO analyses also seem to agree with this rpretation, though metamorphism could have caused an ental oceanic sample to appear circumoceanic for the CaO K_2O analyses.

Figure 36: Comparison of Wasekwan Lake TiO_2, MgO, K_2O and CaO basalt values with those of Chayes, 1964. These analyses support a circumoceanic location of deposition. Striped areas correspond to data from this study.

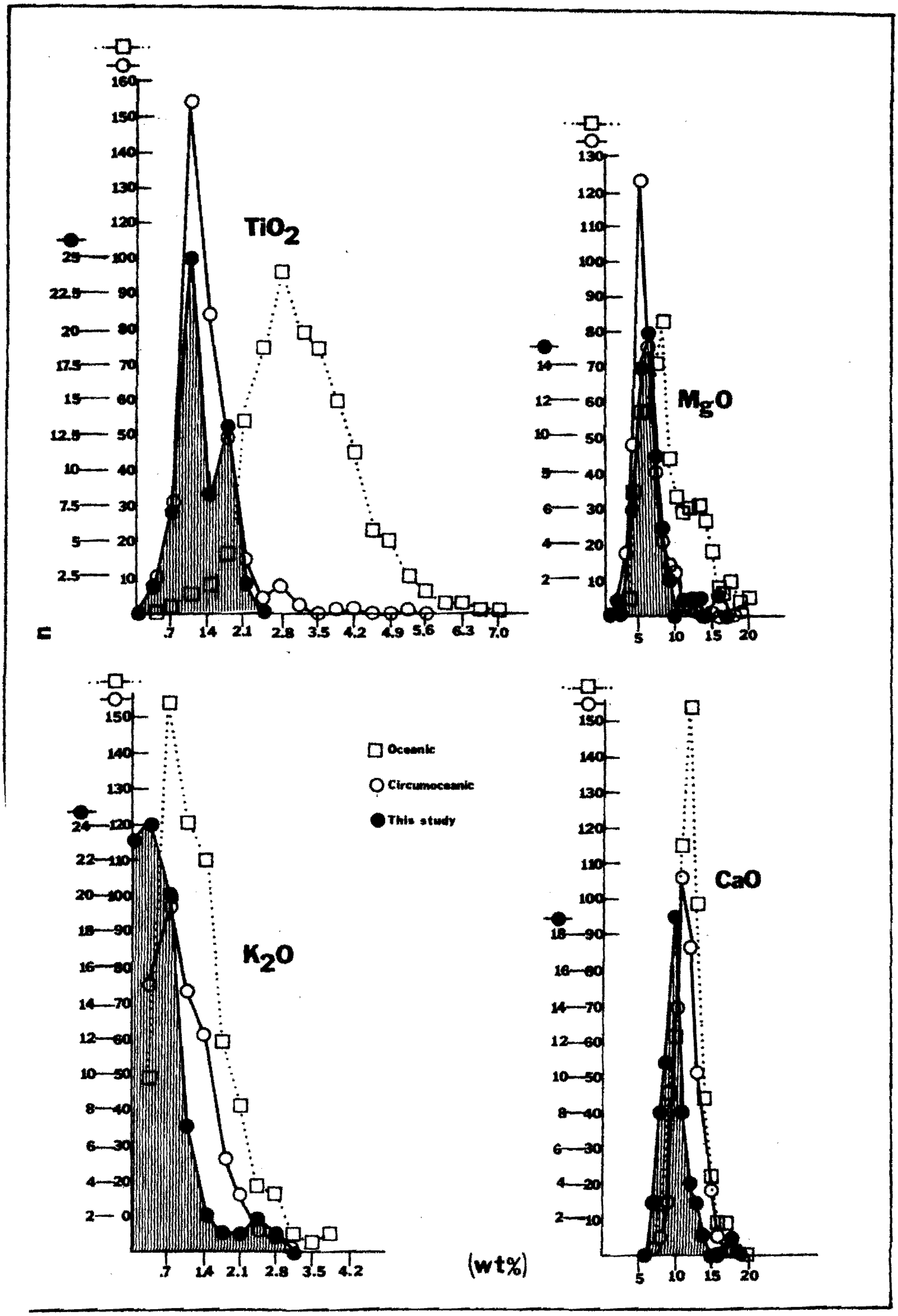

TiO2
MgO
K2O
CaO
n
Oceanic
Circumoceanic
This study
(wt%)

Figure 37: Comparison of Wasekwan Lake SiO_2 and Fe_2O_3 basalt values with those of Chayes, 1964. These analyses give inconclusive results. Striped areas correspond to data from this study.

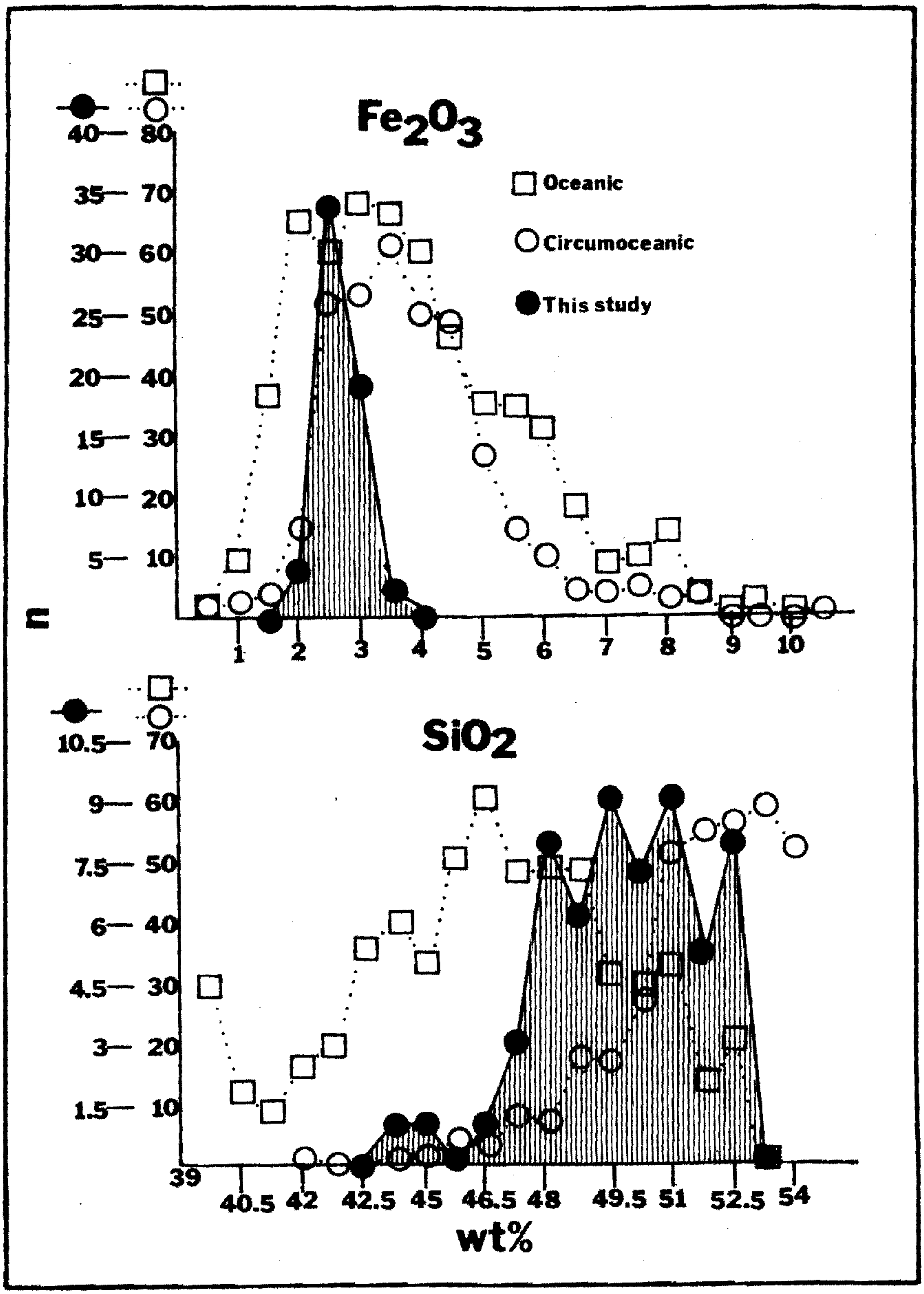
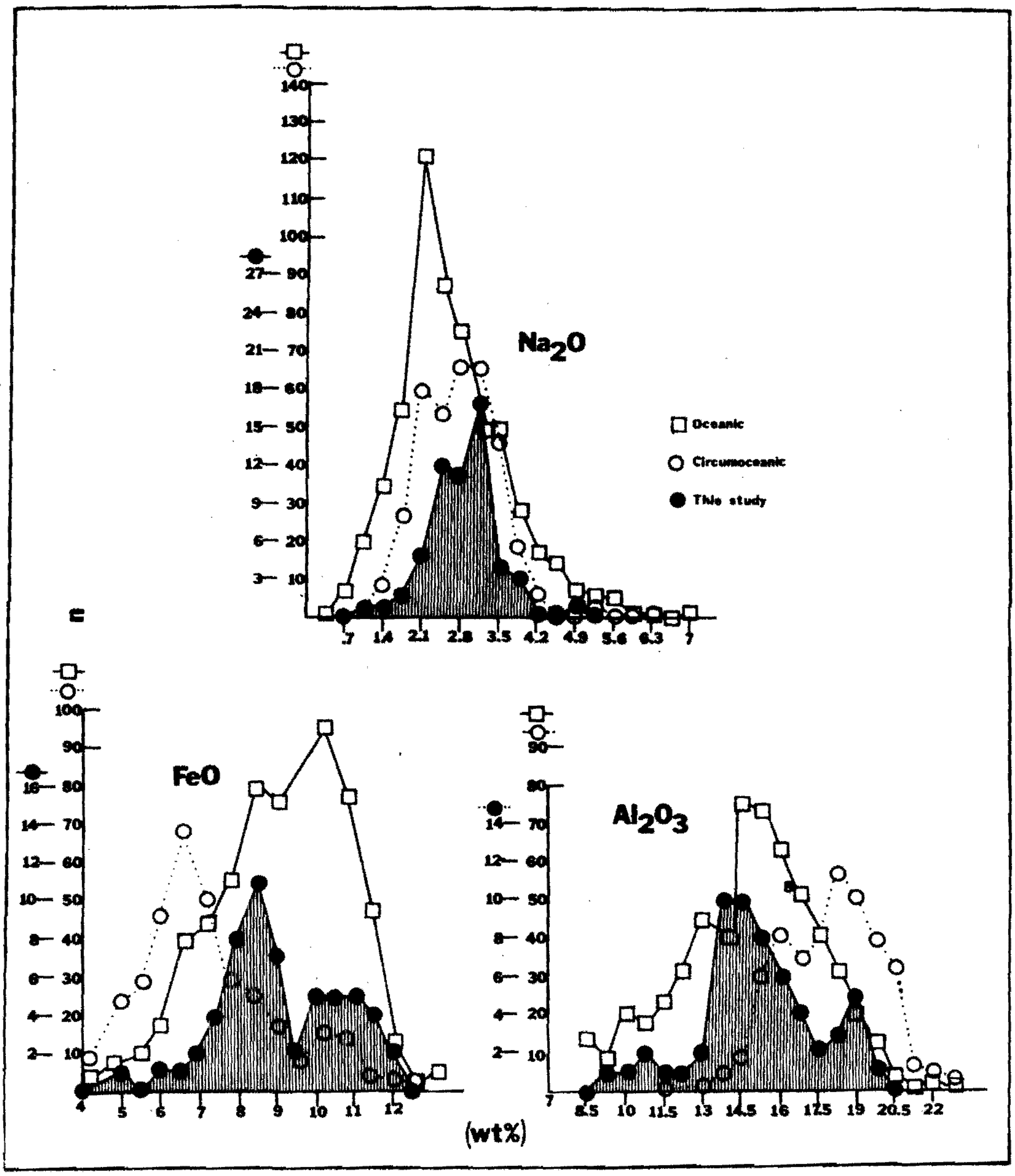

Fe2O3
Oceanic
Circumoceanic
This study
40— 80
35— 70
30— 60
25— 50
20— 40
15— 30
10— 20
5— 10
n
1 2 3 4 5 6 7 8 9 10
SiO2
10.5— 70
9— 60
7.5— 50
6— 40
4.5— 30
3— 20
1.5— 10
39 40.5 42 42.5 45 46.5 48 49.5 51 52.5 54
wt%

Figure 38: Comparison of Wasekwan Lake Na_2O, Al_2O_3 and FeO basalt values with those of Chayes, 1964. These analyses appear to support an oceanic location of depostion. Striped areas correspond to data from this study.



Na2O
Oceanic
Circumoceanic
This study
n
FeO
Al2O3
(wt%)

Figure 37 portrays a confusing display of points. This act is not too surprising, considering that SiO_2 is mobile n both metamorphic and weathering reactions. Iron can also e mobile in both processes and, in fact, secondary magneite in some of the basalts demonstrates that Fe_2O_3 and FeO nderwent significant redistribution relative to their priary concentrations.

Because metamorphism probably increased the FeO conent, this elements "fit" with the oceanic analysis of hayes is explained. Sodium values are also increased durng metamorphism as indicated by the albitization present in he area. This could account for the nondescript "oceanic ppearing" Na plot in Figure 38. Al_2O_3 is also very mobile nd is lost during metamorphism. This again could account or the "oceanic appearing" analysis for this element.

In summary, when taking the metamorphic mobility of ements into account, most plots would probably fall within near the range of Chayes' circumoceanic analyses. Thus, e location of the Cockeram Lake shield was probably on the ndward side of a subduction zone.

A few other observations also support this conclusion. ey are:

1. The general ages and spatial relationship of the volcanic and sedimentary rocks within the area (including the Flin Flon belt) appear to suggest a double island arc system that is analogus to the modern-day

Tonga-Lau system of Hanus and Vanek (1978). The ages and spatial relationship of the volcanic rocks within the Lynn Lake district also suggest an arc mechanism at work, producing a southern older volcanic belt and a northern younger volcanic belt. Sediment derived from these arcs would have been deposited in the fore and back arc basins (Kisseynew and Southern Indian Lake Gneiss belts, for example).

2. It has been demonstrated throughout the literature that many of the island arc subduction systems generate large volumes of andesitic magma (e.g. Aleutian Islands and Cascades of North America). Almost half of the basalt-andesite volcanic rocks in this study fall within this range.
3. The Cockeram Lake volcanic center seems to fit the general model for this type of volcanics. The model fits the modern circumoceanic areas (e.g. Cascades) and involves the evolution of the magma source from an initial tholeiitic basalt and andesite series to a later, much smaller, calc-alkaline stratovolcanic capping sequence.

.3 GOLD MIGRATION AND DEPOSITION WITHIN THE WASEKWAN LAKE AREA

Concentrations within the Brown showing (greater than 0,000ppb) and Central showing (6100ppb) are far above noral background values. In order to understand the reason or the elements present and ultimately be able to intellientlyprospect for this element, a classification of the ype of deposit must be made and theories regarding the oriin, migration and deposition of the element must be dvanced.

.3.1 Classification of the Wasekwan Lake Area Gold Showings

In this study, the classification of the gold deposits ill follow Boyle's nine-fold scheme which is based on the eochemical and geologic setting of the deposits (such as karns, silicified faults, fractures and stockworks, and lacers) rather than on one of the classical schemes which re usually based on the mode of origin of the deposit (such s magmatic, hydrothermal or sedimentary) (Boyle, 1979 p. 9-90). According to Boyle's classification, the deposits ithin the Wasekwan Lake area fit the following:

> "Gold-silver and silver-gold veins, lodes, stockworks, silicified zones, etc. in a complex geological environment, comprising sediments, volcanics and various igneous intrusive and granitized rocks".

5.3.2 Origin of Gold for the Wasekwan Lake Area Deposits

The next area of consideration that must be addressed is the origin of the gold in the deposits. In both the Brown and Central showings, the zones of interest are related to quartz veins or albitite and intrusive dikes, all of which are secondary. Each showing is thus epigenetic. Boyle states that the essential features of these deposits are dependent on preexisting structures and chemically receptive rock. We will see below that these criteria are met for both deposits.

Boyle considers four possible sources for epigenetic gold. Of these four, the theory that best fits the area and is favorable in light of modern advances in geochemistry is the metamorphic secretion theory. According to Boyle:

> "Metamorphic secretion theories as applied to epigenetic gold deposits assume that the gold, silver and gangue elements, initially present in the country rocks, were mobilized and concentrated in available faults, shear zones, fractures and chemical traps (carbonate rocks) during metamorphic events" (Boyle, 1979, p. 390-391).

As was previously noted, the Brown showing is located in a broad area of drag-folding and associated small-scale shearing and the Central showing is located in a highly sheared area. Thus the above essential structural conditions are met for this type of gold deposit.

Table 43 gives an estimation of the gold content of a cubic kilometer for various rock types. Of the types listed, mafic, intermediate and felsic igneous rocks are found in the area in addition to tuffs and greywackes. Many of the rocks thus contained a relatively high primary concentration of gold which could have been drawn upon as the source for the epigenetic deposits. Thus, it is entirely plausible that the original rocks of the area could have contributed gold in large enough concentrations to be the source for the deposits of the area.

5.3.3 Migration and Deposition Theory for the Gold Deposits of the Wasekwan Lake Area.

The migration of gold from the surrounding rocks and its deposition within favorable environments involves mechanisms of mobilization, migration and concentration which are still not clearly understood. It is commonly accepted that when rocks are subjected to the heat of nearby intrusive bodies or conditions of regional metamorphism, complex reactions take place involving the gases of H_2O, HCl, CO_2, CH_4, H_2S, S_2 and larger molecules with the elements of the country rock resulting in the mobilization of water and other volatiles, silica and assorted metals such as Cu, Pb, Zn, Ag and Au (Boyle, 1979 p. 399).

According to Boyle, deposits formed under deep-seated conditions, which include most Precambrian deposits, are formed from diffusion processes once the gold has been released from its bonded site. He has arranged the common elements in groups according to their migration capacities. The following list is in order of decreasing migration tendency:

TABLE 43

ɔld Content of a Cubic Mile and Cubic Kilometer for Various ɣpes of Igneous and Sedimentary Rocks (from Boyle, 1979 p. 398)

ɔck Types (Gold Content in pm in Brackets)		Gold content/mi^3		Gold content/km^3	
IGNEOUS ROCKS		kg	ozx10^6	kg	ozx10^6
ltrabasic	(0.0045)	56,273	1.809	13,500	0.434
asic	(0.0072)	90,036	2.895	21,600	0.694
ntermediate	(0.0047)	58,774	1.890	14,100	0.453
cid	(0.0027)	33,764	1.086	8,100	0.260
EDIMENTARY ROCKS					
andstone, arkose onglomerate, etc.	(0.0263)	328,882	10.574	78,900	2.537
hale, mudstone, rgillite, etc.	(0.0039)	48,770	1.568	11,700	0.376
ulphidic schists, yritic black hale, etc.	(0.0143)	178,822	5.749	42,900	1.379
uffs	(0.0023)	28,762	0.925	6,900	0.222
imestone, dolomite	(0.0034)	42,517	1.367	10,200	0.328
reywacke and ubgreywacke	(0.0076)	95,03	3.055	72,800	0.733

<u>Gangue elements</u>:

Si,B,K,Na,Ca=Mn,Mg,Co,Fe=Ni,Al

<u>Gaseous compounds</u>:

CO_2=S=Se,As,Sb,Te

<u>Base metals</u>:

Hg,Zn,Cd,Co,Pb,Mo=Bi=Sn=W

<u>Precious metals</u>:

Ag,Au,Pt

This list is based on the thermodynamic properties, diffusitivity, binding energies in lattices, ability to form soluble complexes, solution properties under different Eh/pH conditions and the ability to form colloids (Boyle, 1979 p. 22).

It should be noted at this point that both deposits within the area show some type of local alteration halo in addition to the regional alteration. Briefly, the types of alteration present in the area as classified by Boyle (1979 p. 208-209) are:

1. Feldspathization is the most visible of all alteration in that it occurs in most of the rock types and the process involves the development of secondary feldspars of which albite is the most common. The importance of this process is indicated by the presence of gold in an albitite dike at the Central showing.

2. Tourmalinization plays only a minor role and is best displayed in the tourmalinized subvolcanic intrusive (1) of the Rabbit's claim.
3. Silicification involves the formation of secondary quartz in the country rocks. This is demonstrated throughout the area by the presence of quartz veins. The presence of gold-bearing quartz veins in the Brown showing further indicates the importance of this process.
4. Chloritization involves the introduction of H_2O and removal of SiO_2 and occurs at and around both of the showings. In addition, extensive areas of chloritization occur within the rocks of the Cartwright Lake shear, indicating the importance of this process in the final chemical makeup of the area.
5. Sericitization involves the development of sericite and/or hydromuscovite as a result of the hydration of feldspars. The process involves the removal of SiO_2, Fe and Ca and the introduction of K and H_2O, and is evident at the two gold showings and throughout the area.
6. Carbonatization involves the formation of secondary carbonates and the removal of SiO_2. This process has occurred throughout the area and calcite veins are observed at both gold showings.

7. Sideritization is separated from carbonatization by Boyle and involves the formation of siderite. The results of this process can be found at the Central showing with the occurrence of siderite within the albitite dike.
8. Pyritization has occurred throughout the area, but is especially prevalent in sheared areas as well as at both showings.
9. Propylitization involves the formation of chlorite, epidote, carbonates, sericite, feldspars and pyrite, all of which are common in the area. Propylitization usually involves the addition of CO_2, S and As with SiO_2 losses. Na and K may be added or subtracted during this process.
10. Hydration involves the introduction of water that is fixed as a hydroxyl or as the water of hydration. Many of the rocks along the shear have compositions that are consistent with this type of alteration.
11. Beresitization is included in Boyles' discussion of alteration. The term is commonly used in the U.S.S.R. and applied to granitic rocks that are heavily sericitized, albitized and impregnated with pyrite. This process played a dominant role in portions of 17 along the Cartwright Lake shear.

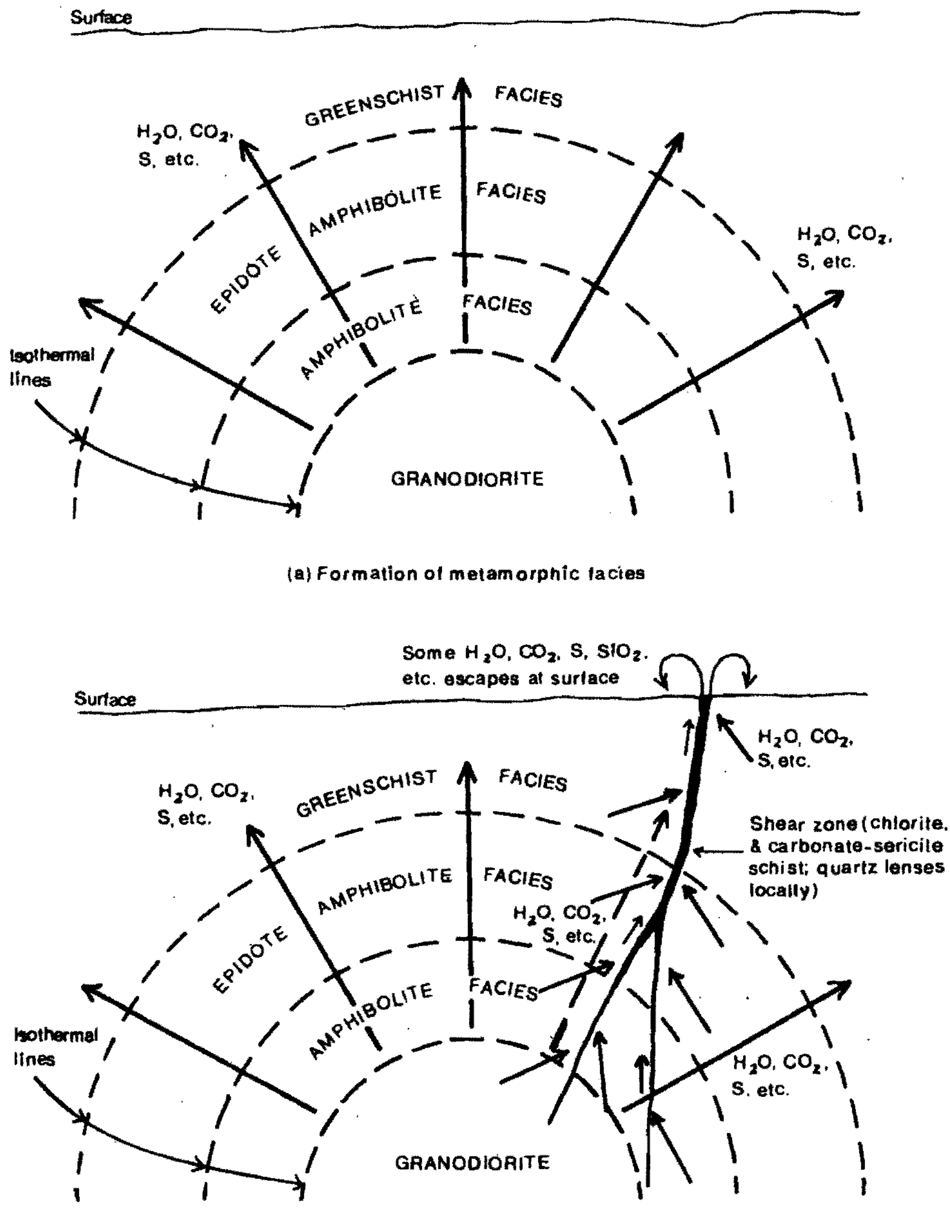
The presence of such extensive alteration both in the country rocks and the local gold showings indicates a complex chemistry of formation for the deposits.

One of the principal factors in the migration and deposition of elements in the area involves shearing as evidenced by the Cartwright Lake shear zone and the local shearing at the showings. The Cartwright Lake shear probably played a major role in element migration because of its great length and probable depth. This structure probably became a pathway for the elements due to its accessibility to large volumes of surrounding rock. Because of the lower pressure regime of the shear, the mobile elements of carbon dioxide, water, and sulfur were literally pulled from the surrounding rock and channeled away from the higher temperature and pressure metamorphic centers. Boyle states that the mobile elements probably originated from areas thousands of feet horizontally and vertically from these types of shear zones (Boyle, 1979 p.400). The role of metamorphic facies and shear zones are demonstrated in figure 39 as they pertain to ion migration. This model fits the Wasekwan Lake area very well.

Once the mechanics of this model have been put into motion, Boyle advances a model whereby gold can be deposited into first- and second-degree dilatant zones (Figure 40).

The large shear zones, which act as chemical pathways, are called first-degree dilatant zones. During their formation, CO_2, H_2O, and S become abundant, the consequence of which is a strongly displaced chemical equilibrium that results in the chloritization, carbonitization and

Figure 39: The effect of metamorphic facies and shear zones on ion migration (from Boyle, 1979, p. 402).

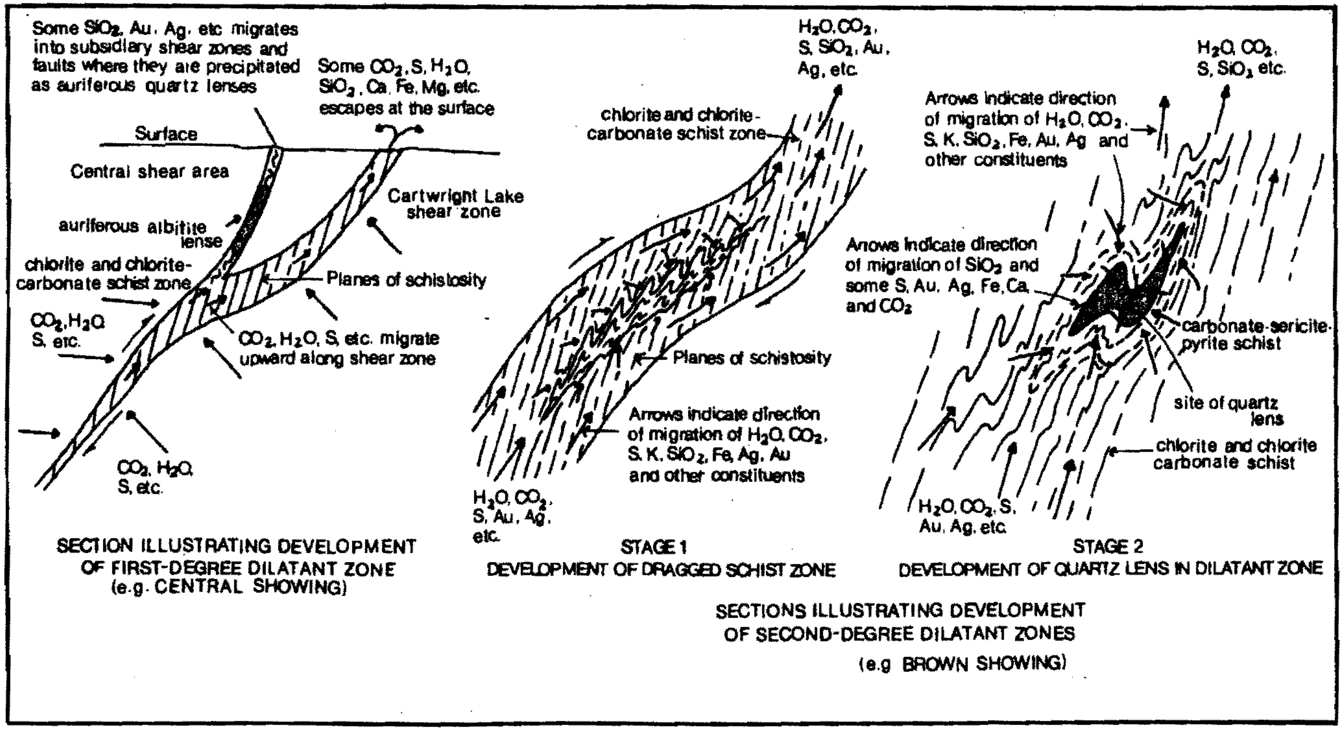


(a) Formation of metamorphic facies

(b) Formation of auriferous shear zones

Note: Arrows indicate direction of migration of H_2O, CO_2, S, As and other elements

Figure 40: Model for the migration and deposition of gold and its associated elements in the Wasekwan Lake area (from Boyle, 1979 p. 425).



SECTION ILLUSTRATING DEVELOPMENT OF FIRST-DEGREE DILATANT ZONE (e.g. CENTRAL SHOWING)

SECTIONS ILLUSTRATING DEVELOPMENT OF SECOND-DEGREE DILATANT ZONES (e.g BROWN SHOWING) ritization of the host rocks. This produces a liberation Si, K, Ca, Na, Fe, etc. as well as precious metals, from e affected rocks. These elements, with those added to the ear by diffusion from the surrounding formation, could grate laterally and vertically to "second-degree" low-essure dilatant zones at shear junctions and other locales ere low-pressure or low chemical reactions are promoted. is would result in the precipitation of quartz, carbo-tes, albite and gold lenses with their associated altera-on haloes. A more complete discussion of this mechanism n be found in Boyle, (1979 p. 406-430).

From the discussion above, it appears that both the own showing and Central showing have very similar origins, ough they appear quite different at first glance. Both e epigenetic and depend on the diffusion of elements rough the country rock, aided by regional and local shear-g. The Central showing was deposited in a subsidiary ear zone in a first-degree dilatant zone (Cartwright Lake ear zone). Combined regional drag-folding and local dila-nt zones, as in Boyles's second-degree dilatant zone igure 40), resulted in the deposition of the Brown show-g.

A few special notes:

1. Many of the quartz veins in the Brown showing appear to have been emplaced in country rocks that had a contorted "S" or "Z" shape similar to those of the

sketch in figure 40, this fact substantiates that dilatant mechanisms were at work in the formation of this deposit.

2. Drilling during the winter of 1981, in the Central showing area, has verified a local subsidiary shear which dips toward, and probably meets at depth with, the Cartwright Lake shear (C. Taylor, personal communication). Other albitite occurrences are found at depth and verify the dike-like emplacement of this body.

Chapter VI

SUMMARY

.1 GEOLOGIC HISTORY

The emplacement of the units of the Wasekwan Lake area nd subsequent structural and metamorphic modifications are ummarized below. The author has accepted the order of sucession and models as the best working hypotheses:

1. 1790-1835 m.y. ago, the distribution of forces within the present day Lynn Lake area were such that subduction was initiated, which ultimately resulted in a double island arc system of volcanoes.
2. Tholeiitic basaltic and andesitic magma was generated from this process, resulting in the extrusion and deposition of a volcanic island platform (Cockeram Lake shield). This was not the first appearence of such volcanics but this center was isolated from other volcanic centers.
3. Volcanism and associated sedimentation continued in the area, building up the shield to near sea level.
4. A late-stage stratovolcano was formed as a capping succession on the Cockeram Lake shield. It was composed predominantly of calc-alkaline intermediate and dacitic tuffs. This volcanism occurred at or about

the time of the shields' emergence from the surrounding seas.

5. During the emplacement of the above volcanic and sedimentary rocks, subvolcanic sills, dikes and feeder systems were emplaced.
6. After the deposition of the Wasekwan series, a series of mafic to felsic intrusives was emplaced. One such intrusive (unit 17) was emplaced into an eastward faulted area as a sill. Later structural events produced the Cartwright Lake shear zone in this area.
7. Five episodes of structural development were introduced to the area resulting in the complex folding, faulting, tilting, shearing and erosion of the units. During these events, the upper-greenschist to albite-epidote amphibolite metamorphic facies was imprinted on the rocks, resulting in the metamorphic mineral assemblages and foliations that are found in the area.
8. The fourth deformation event resulted in the formation of a very large, east-striking dextral strike-slip fault zone (Cartwright Lake shear).
9. The fourth and fifth deformation events resulted in regional metamorphism and anatexis, giving rise to abundant ion migration from the surrounding country rocks into and through the previously formed shear systems. Diffusion was the dominant method of migration.

10. The rocks of the main shear zones, as well as the subsidiary shear zones, in acting as pathways for the mobile elements, were altered to a retrograde green-schist metamorphic facies. These areas underwent feldspathization, tourmalinization, chloritization, sericitization, carbonatization, sideritization, pyritization, propylitization, silicification, hydration and beresitization.
11. One subsidiary shear zone became the site of deposition for such elements as Na, Au and Ag in the form of gold-bearing albitite dike swarms. Alteration halos are associated with this deposit. This area is now the Central showing.
12. Another area underwent broad drag-folding and developed dragged schist zones which acted as second degree dilatant zones. Such elements as SiO_2, Au and Ag migrated into the low pressure environments of these zones and became deposited in the form of gold-bearing quartz veins. Associated alteration halos were also present.
13. Subsequent uplift and erosion brought the present day surface to view.

2 RECOMMENDATIONS FOR FUTURE STUDY

Many future studies could be instigated that would ing about a further understanding of the processes that curred in the formation and alteration of the study area. me suggestions are:

1. Rare earth analyses could be initiated to further characterize and classify the rocks.
2. Further examination of the chemical data could be done in order to chemically subdivide some of the units.
3. The present chemical data could also be studied so as to better document the elemental distribution around a given showing, which would aid in the understanding of specific migration tendencies within these rocks. The results could be used to construct a larger scale elemental map and/or ratio map which would aid in the prospecting of the area or a similar area for other deposits of interest.
4. Work with isotopes, such as oxygen and sulfur, would establish the temperature of formation of these sub-economic ore bodies. This would verify the migration and deposition models for the deposits, thereby aiding in future exploration for similar deposits.

APPENDICES

Appendix A

WHOLE-ROCK CHEMICAL ANALYSES AND THIN SECTION DESCRIPTIONS

The whole-rock chemical analyses and thin section əscriptions are arranged serially according to geochemistry ample numbers. The major oxides are given in weight per ənt values and the minor and trace elements are given in arts per million (ppm), except for gold which is given in arts per billion (ppb). Thin section descriptions are iven below each geochemical numbered sample. The descrip- ions are arranged by giving the geochemical number followed y the rock type, subunit designation, location that the ample was collected from (claim or showing name) and a rief thin section description.

Abbreviations used in this appendix are:

n-------plagioclase anorthite content
io------biotite
g-------coarse-grained
t-------greater than
nt------intermediate
g-------medium-grained
m-------millimeters
usc-----muscovite
lag-----plagioclase
tz------quartz
fg------very fine-grained

AMPLE	001	002	003	004	005	006
iO2	52.5	53.9	51.4	56.7	63.9	69.9
l2O3	17.2	15.9	17.4	15.5	13.5	16.9
e2O3	2.20	4.69	3.03	1.89	1.95	1.13
eO	7.2	3.8	7.8	4.9	5.2	0.6
aO	5.97	4.90	6.90	6.36	3.80	0.34
gO	1.94	3.07	3.10	2.01	1.00	0.40
a2O	1.94	2.02	2.58	2.70	3.18	4.79
2O	3.50	2.64	0.51	1.73	1.26	2.79
$2O^+$	1.2	1.7	2.1	2.0	1.6	1.1
$2O^-$	.2	.3	.1	.2	.2	.2
.O2	.79	.67	.91	.52	.54	.25
2O5	.11	.13	.10	.07	.09	.06
nO	.14	.14	.17	.13	.14	.01
)2	3.2	4.0	2.7	3.8	1.7	.3
)3	.065	.469	.050	.120	.005	.000
TAL	98.2	98.3	98.9	98.6	98.1	98.8
	9.0	150.	97.0	95.0	46.0	10.0
	< .5	.5	< .5	.5	< .5	< .5
	<2.	3.	<2.	5.	3.	<2.
	140.	90.0	110.	85.0	95.0	13.0
	30.	10.	20.	10.	20.	0.
	4.	6.	°2.	6.	<2.	<2.
	60.	70.	80.	50.	90.	100.
	1.	3.	3.	2.	<1.	5.
	1.2	1.7	1.7	1.2	1.1	.6
	170.	170.	250.	140.	13.	25.
	24.	75.	21.	27.	31.	38.
	2.0	4.0	1.0	3.5	2.5	.5
	15.0	26.0	26.0	16.0	4.5	2.5
	< .5	14.0	< .5	< .5	< .5	2.0

1, 010 altered mafic tuff (4fa), fg anhedral plag in vfg schistose matrix of musc, qtz, calcite phyllonitic structure

2 altered mafic tuff (4fa), (Mirage) fg, anhedral, plag in a vfg schistose matrix of qtz, musc, siderite and plag, phyllonitic structure, minor shearing

3 altered mafic tuff (4fa), (K-fir), intensly altered and recrystallized, sheared, foliated

4 dacitic tuff (5b), (K-fir) fg qtz, plag and opaques in a very foliated matrix of qtz, plag, musc and chlorite, highly altered and sheared

5 dacitic tuff (5b), (K-fir), fg qtz, plag and opaques in a vfg, very schistose, sheared matrix of qtz, plag, chlorite and calcite, highly altered

6 qtz vein, trench #1 (K-fir), minor sulfide mineralization, bleached tuff(?) host

SAMPLE	007	008	009	010	011	012
SiO2	56.5	56.5	48.1	52.5	48.5	48.0
Al2O3	18.1	15.4	14.2	16.4	14.0	9.20
Fe2O3	3.74	3.66	4.64	2.41	2.07	2.66
FeO	4.3	4.0	6.8	7.1	8.4	9.3
CaO	4.27	7.14	8.34	6.39	8.84	11.5
MgO	2.97	4.02	5.18	2.02	2.84	11.6
Na2O	2.56	2.29	2.35	1.83	3.14	1.71
K2O	2.27	2.85	.21	3.30	.63	.50
H_2O^+	2.1	1.0	3.0	1.8	2.7	1.3
H_2O^-	.2	.2	.2	.2	.2	.2
TiO2	.74	.67	.84	.78	.82	1.21
P2O5	.13	.18	.14	.10	.06	.58
MnO	.12	.17	.21	.16	.24	.21
CO2	1.0	1.0	4.4	3.5	6.2	.2
SO3	.135	.050	.000	.055	.050	.010
TOTAL	99.1	99.1	98.6	98.5	98.7	98.2
Cu	72.0	270.	53.0	11.0	190.	56.0
Ag	< .5	1.0	< .5	< .5	< .5	< .5
Au	< 2.	2.	< 2.	< 2.	9.	< 2.
Zn	83.0	130.	140.	150.	140.	19.0
Y	0.	20.	10.	0.	20.	30.
Pb	< 2.	4.	6.	2.	8.	4.
Zr	80.	50.	40.	50.	10.	50.
As	5.	6.	5.	1.	1.	4.
Sb	.3	.8	.7	1.7	1.2	.2
V	170.	290.	280.	160.	300.	250.
Cr	58.	99.	51.	24.	21.	311.
Mo	1.5	1.5	3.0	1.5	3.0	2.5
Co	16.0	29.0	31.0	16.0	21.0	9.5
Ni	15.0	39.0	< .5	< .5	.5	25.0

007 dacitic tuff (5b), (K-fir), fg bio and opaques in a vfg, very schistose, highly contorted and sheared matrix of qtz, musc, plag, highly altered

008 altered mafic tuff (4fa), (K-fir), highly altered and recrystallized, sheared, calcite and qtz veins, sheared, epidotized

009 altered mafic tuff (4fa), (K-fir), highly altered and recrystallized, sheared, calcite veins, foliated

010, 001 altered mafic tuff (4fa), fg prophyroblastic, anhedral plag in vfg, schistose matrix of musc, qtz, calcite, phyllonitic strucure

011, 020 int tuff (5a), (Mirage), fg porphyroblastic, anhedral plag in vfg schistose matrix of plag, chlorite, calcite and qtz, sheared, carbonate veins

012 porphyritic gabbro (13), (Viggen), porphyritic hornblende psuedomorphs (to 9mm) with interstitial plag

PLE	013	014	015	016	017	018
2	47.8	50.5	47.5	50.9	67.3	65.6
O3	14.6	14.7	18.1	14.3	12.5	15.0
O3	5.82	2.74	2.75	3.26	1.82	3.24
)	6.1	7.7	9.4	9.3	3.6	.9
)	11.0	10.5	10.7	8.51	3.88	3.02
)	7.14	6.13	4.39	5.41	1.38	1.02
O	1.86	2.90	2.60	2.96	3.46	4.76
)	.75	.34	.28	.52	.60	1.74
+	2.1	.6	.8	1.2	1.5	1.0
−	.3	.2	.2	.3	.2	.2
2	.79	.93	.93	.19	.42	.23
5	.15	.16	.05	.12	.08	.07
)	.23	.20	.21	.22	.09	.08
	.2	.9	.3	.4	1.5	1.7
	.000	.020	.000	.015	.035	1.149
AL	98.8	98.5	98.2	98.6	98.4	99.7
	6.5	50.0	100.	63.0	15.0	84.0
	< .5	< .5	< .5	.5	< .5	.5
	< 2.	< 2.	7.	4.	< 2.	< 2.
	61.0	17.0	23.0	31.0	62.0	30.0
	20.	10.	0.	10.	30.	10.
	< 2.	6.	4.	4.	< 2.	4.
	20.	40.	10.	70.	70.	70.
	5.	6.	14.	2.	3.	1.
	1.0	1.3	.6	2.4	.9	1.2
	300.	260.	340.	310.	46.	33.
	96.	62.	34.	48.	41.	34.
	.5	4.5	3.0	3.0	3.0	4.0
	22.0	9.5	15.0	8.5	4.5	5.0
	23.0	17.0	2.5	3.5	< .5	4.5

altered mafic tuff (4fa), (K-fir), highly altered and recrystallized, sheared, qtz veins, epidotized
massive aphyric basalt (4b), (Mirage), no primary texture preserved
basalt check
amygdaloidal basalt (4d), (Tornado), plag filled amygdales, "relict" opaques, minor qtz veins, foliated
int tuff (5a), (K-fir), fg prophyroblastic anhedral plag and qtz in a vfg schistose matrix of qtz, plag, and chlorite, highly sheared and fractured
granodiorite dike (17), (Mirage), cataclastic plag microcline and qtz crystoblasts in a fg schistose matix of qtz, plag and musc, flaser structure, schistose, sheared

SAMPLE	019	020	021	022	023	024
SiO_2	66.0	51.5	63.2	58.1	53.0	65.9
Al_2O_3	12.4	12.9	15.4	15.0	15.8	16.4
Fe_2O_3	1.41	1.72	1.40	1.78	3.06	1.09
FeO	3.6	7.3	3.3	5.7	5.5	2.3
CaO	3.79	9.49	3.41	6.16	8.78	3.04
MgO	.89	2.40	1.64	3.52	5.96	1.00
Na_2O	4.7	3.28	2.59	3.21	2.93	4.29
K_2O	1.06	.51	3.11	.84	.47	2.76
H_2O^+	1.1	2.4	1.3	1.4	1.4	.6
H_2O^-	.2	.2	.2	.1	.1	.2
TiO_2	.62	.72	.29	.57	.66	.32
P_2O_5	.18	.06	.07	.10	.12	.13
MnO	.14	.24	.10	.14	.17	.07
CO_2	2.0	6.7	2.1	1.4	1.9	.3
SO_3	.015	.080	.120	.040	.045	.000
TOTAL	98.1	99.5	98.2	98.1	99.9	98.4
Cu	6.5	240.	45.0	91.0	140.	9.0
Ag	.5	.5	.5	.5	.5	< .5
Au	<2.	9.	2.	16.	29.	<2.
Zn	52.0	130.	52.0	63.0	44.0	51.0
Y	50.	0.	20.	40.	10.	10.
Pb	4.	10.	4.	4.	6.	6.
Zr	170.	20.	80.	60.	40.	150.
As	1.	<1.	1.	1.	3.	9.
Sb	.7	1.3	.7	1.0	.3	.9
V	30.	230.	35.	130.	190.	33.
Cr	41.	24.	34.	65.	92.	55.
Mo	3.0	4.5	4.5	3.0	4.0	2.0
Co	5.0	21.0	7.5	10.0	11.0	6.0
Ni	< .5	< .5	2.0	11.0	25.0	5.0

019 dacitic tuff (5b), (Mirage), fg plag porphyroblasts in a very schistose and sheared matrix of plag, qtz and calcite, highly altered

020, 011 int tuff (5a), (Mirage), fg prophyroblastic anhedral plagioclase in a vfg schistose matrix of plag, chlorite calcite and qtz, sheared and carbonate veins

021, 030 dacitic tuff (5b), (Mirage), fg qtz, plag, opaques in a vfg schistose and sheared matrix of qtz and musc, qtz veins

022 int tuff (5a), (Mirage), fg plag porphroblasts in a predominately vfg slightly schistose mosaic groundmass of plag, qtz, and musc, phyllonitic and sheared

023 greywacke (9a), (Mirage), hornblende and chlorite-bearing greywacke, possible shearing, foliated

024 granodiorite (16a), (Viggen), mg, anhedral, myrmekitic zoned plag, fg qtz, idiomorphic, crushed

SAMPLE	025	026	027	028	029	030
SiO2	56.2	64.9	67.7	50.0	61.3	64.0
Al2O3	16.3	16.7	16.4	15.2	14.3	15.8
Fe2O3	1.14	3.37	.29	2.95	.67	1.30
FeO	7.6	10.0	2.2	7.6	7.8	3.1
CaO	3.49	3.11	1.87	9.12	3.82	3.09
MgO	3.39	1.06	.71	5.39	3.82	1.54
Na2O	4.44	4.27	4.62	3.13	1.40	2.60
K2O	1.02	3.12	3.35	1.08	1.93	3.32
$H2O^+$	2.4	.8	.6	1.2	2.7	1.6
$H2O^-$	.2	.2	.2	.2	.2	.3
TiO2	.80	.34	.27	.95	.84	.31
P2O5	.16	.14	.11	.09	.14	.07
MnO	.12	.08	.05	.21	.10	.09
CO2	2.1	.4	.8	1.9	.5	1.8
SO3	.210	.005	.000	.010	1.214	.075
TOTAL	99.6	108.5	99.2	99.0	100.7	99.0
Cu	47.0	7.5	2.5	80.0	71.0	31.0
Ag	< .5	< .5	< .5	.5	.5	< .5
Au	52.	<2.	<2.	9.	9.	<2.
Zn	100.	63.0	40.0	39.0	100.	45.0
Y	30.	10.	20.	20.	30.	20.
Pb	4.	4.	8.	6.	4.	4.
Zr	50.	180.	130.	60.	150.	80.
As	19.	7.	5.	2.	2.	2.
Sb	.9	1.3	.6	.3	.3	.5
V	170.	34.	24.	310.	170.	35.
Cr	34.	55.	41.	51.	38.	34.
Mo	1.5	1.5	3.0	4.5	1.0	3.5
Co	17.0	8.5	6.5	16.0	22.0	6.0
Ni	< .5	8.0	6.0	12.0	1.0	1.5

025 int tuff (5a), (Mirage), cataclastic, fg, porphyroblastic plag in a vfg breccia matrix of qtz, plag and chlorite, highly sheared

026 granodiorite (16a), (Viggen), mg, anhedral zoned plag, fg qtz, recrystallized microcline, idiomorphic

027 granodiorite (16a), (Viggen), subhedral porphyritic plag and microcline, fg qtz, hypidiomorphic

028 greywacke (9a), (Mirage), hornblende-bearing greywacke with abundant plag, foliated

029 laminated siltstone (9b), (Tornado), laminations defined by amphibole content, sheared, fractured,

030, 021 dacitic tuff (5b), (Mirage), fg qtz, plag, opaques in a vfg schistose and sheared matrix of qtz and musc, qtz veins

MPLE	031	032	033	034	035	036
O2	56.2	56.3	66.9	53.4	54.7	66.2
2O3	15.5	15.6	16.1	17.6	17.1	16.0
2O3	2.15	2.12	1.96	1.55	2.33	1.49
O	7.6	7.9	1.4	6.5	4.4	1.8
O	5.30	4.97	2.40	7.25	6.59	1.97
O	3.08	3.15	.98	4.37	3.10	.98
2O	3.16	3.12	4.48	3.30	4.88	4.53
O	.57	.59	2.97	1.47	1.12	3.11
O^+	3.4	3.2	.6	1.3	1.0	.8
O^-	.3	.1	.2	.2	.2	.2
O2	.83	.85	.33	.90	.73	.33
O5	.13	.14	.14	.32	.26	.14
O	.16	.16	.06	.13	.11	.05
2	1.4	1.2	.4	.2	1.9	.8
3	.015	.000	.000	.000	.035	.000
TAL	99.8	99.4	98.9	98.5	98.5	98.4
	14.0	6.5	37.0	14.0	170.	8.0
	< .5	< .5	< .5	.5	.5	< .5
	<2.	<2.	<2.	27.	8.	<2.
	130.	130.	50.0	60.0	58.0	58.0
	10.	20.	20.	10.	10.	10.
	2.	2.	8.	2.	5.	10.
	50.	60.	180.	100.	90.	170.
	4.	4.	1.	3.	2.	6.
	1.6	1.2	.2	.8	.6	.9
	180.	170.	31.	180.	180.	33.
	34.	34.	44.	48.	44.	48.
	1.5	1.0	6.5	2.0	3.5	3.5
	19.0	19.0	1.5	16.0	14.0	6.5
	< .5	< .5	5.5	14.0	15.0	6.0

1, 032 int lapilli tuff (5a), (Mirage), fg anhedral porphyroblasitc plag in hornfelsic matrix of plag and qtz, andularia-calcite veins, lapilli fragments

2, 031 int lapilli tuff (5a), (Mirage), fg anhedral porphyroblastic plag in hornfelsic matrix of plag and qtz, andularia-calcite veins, lapilli fragments

3 granodiorite (16a), (Viggen), mg twinned myrmekitic plag (An_{26}) and fg qtz, minor qtz veins

4 gabbro (13), (Viggen), plag-rich (An_{27}) amphibolite

5 greywacke (9a), (Mirage), cataclastic hornblende-bearing greywacke with plag, sheared, foliated

6 granodiorite (16a), (Viggen), porphyritic plag and microcline, fg qtz, idiomorphic

AMPLE	037	038	039	040A	040B	041
iO2	48.9	49.8	49.1	47.8	47.6	47.9
12O3	18.3	13.5	17.5	18.3	18.0	18.6
e2O3	2.50	3.30	2.37	2.33	2.74	2.64
eO	7.2	10.8	7.5	9.6	9.5	7.7
aO	9.56	7.53	10.2	10.5	10.7	9.40
gO	5.20	5.07	5.32	4.16	4.30	5.52
a2O	3.29	3.04	2.88	2.61	2.66	3.16
2O	.59	.38	.51	.29	.28	.53
$2O^{+}$	1.1	1.7	1.6	1.2	1.1	1.3
$2O^{-}$	.2	.2	.2	.2	.2	.1
iO2	.90	1.49	.87	.92	.95	.92
2O5	.10	.26	.08	.04	.04	.09
nO	.17	.24	.17	.21	.21	.18
O2	.3	.7	.4	.2	.2	.1
O3	.020	.060	.070	.015	.000	.035
OTAL	98.3	98.1	98.8	98.4	98.6	98.2
u	21.0	25.0	78.0	95.0	91.0	23.0
g	< .5	< .5	.5	< .5	< .5	< .5
u	7.	<2.	2.	7.	13.	<2.
n	26.0	56.0	18.0	20.0	19.0	30.0
	30.	30.	20.	0.	10.	10.
o	6.	°2.	4.	4.	4.	4.
:	50.	50.	50.	0.	0.	40.
s	4.	1.	4.	9.	12.	2.
o	1.6	.5	1.7	1.0	.9	2.1
	240.	520.	250.	350.	380.	250.
:	48.	41.	58.	27.	27.	51.
)	3.5	2.5	3.5	3.5	3.5	3.0
)	9.5	14.0	18.0	15.0	15.0	11.0
	10.0	9.5	9.5	2.0	2.5	9.0

7, 041 amygdaloidal basalt (2d), (Mirage), unfoliated plag filled and polymineralic amygdales, "relict" opaques

8 massive andesite (2a), (Mirage), completely recrystallized, qtz and calcite veins, fractured

9 amygdaloidal basalt (2d), (Mirage), unfoliated plag filled and polymineralic amygdales, minor myrmekitic plag, very minor shearing

0A basalt check

0B basalt check

1, 037 amygdaloidal basalt (2d), (Mirage), unfoliated plag filled and polymineralic amygdales, "relict" opaques

SAMPLE	042	043	044	045	046	047
SiO2	59.6	59.7	48.6	52.3	61.2	69.8
Al2O3	16.5	14.7	18.8	13.2	14.3	16.3
Fe2O3	1.89	3.59	2.24	2.92	3.24	1.44
FeO	6.9	5.1	7.7	11.5	5.3	.6
CaO	3.97	5.01	7.28	7.53	4.46	.57
MgO	2.56	1.75	3.23	4.34	1.26	.46
Na2O	3.58	3.13	2.94	2.18	4.17	5.30
K2O	2.08	.94	.90	.38	.60	2.35
H_2O^+	1.4	2.0	3.6	1.0	1.3	.4
H_2O^-	.2	.3	.2	.2	.2	< .1
TiO2	.75	.60	.93	1.68	.76	.27
P2O5	.13	.08	.11	.32	.12	.06
MnO	.12	.17	.17	.24	.14	.04
CO2	.2	2.0	3.2	.5	2.1	< .1
SO3	.115	.634	.000	.524	.594	.060
TOTAL	100.0	99.7	99.9	99.4	99.7	97.8
Cu	43.0	200.	53.0	110.	100.	14.0
Ag	.5	< .5	.5	< .5	< .5	< .5
Au	<2.	<2.	12.	<2.	5.	3.
Zn	110.	98.0	95.0	27.0	72.0	11.0
Y	20.	20.	10.	30.	50.	0.
Pb	<2.	4.	4.	<2.	4.	<2.
Zr	40.	90.	30.	100.	70.	90.
As	6.	6.	2.	1.	2.	4.
Sb	.2	2.5	1.0	1.0	1.1	.5
V	170.	110.	300.	470.	44.	25.
Cr	34.	31.	17.	38.	31.	38.
Mo	< .5	3.0	2.5	2.5	2.5	1.0
Co	14.0	19.0	22.0	13.0	17.0	2.5
Ni	< .5	< .5	< .5	9.0	< .5	1.5

042 greywacke (9a), (Mirage), plag-rich, musc, penninite and amphibole-rich greywacke, minor shearing, fractured, poor foliation

043 dacitic tuff (5b), (Mirage), fg qtz and plag porphyroblasts in a vfg gneissic matrix of qtz, plag, calcite

044 altered mafic tuff (4fa), (Mirage), sheared, layers of plag, qtz and chlorite

045 amygdaloidal andesite (2a), (Mirage), polymineralic amygdales, "relict" opaques, qtz veins, foliated

046 int tuff (5a), (K-fir), fg anhedral porphyroblastic plag in a highly sheared matrix of qtz, plag, penninite and calcite, phyllonitic, flaser, possible lapilli

047 qtz vein, trench #3, K-fir claim, minor sulfide mineralization, bleached tuff(?) host

MPLE	048	049	050	051	052	053
)2	57.9	50.09	48.5	69.2	69.2	59.6
2O3	15.3	14.2	15.3	15.5	15.6	14.2
2O3	3.73	1.95	3.90	.94	1.54	3.20
)	4.2	9.4	7.2	.9	.2	4.8
)	5.95	6.93	9.68	2.31	1.79	5.91
)	4.01	4.39	6.31	.56	.36	3.58
2O	3.72	2.05	2.75	4.83	5.1	3.08
)	1.06	1.69	.70	2.66	2.62	1.81
)$^+$	1.0	3.0	1.1	.5	.8	.8
)$^-$	< .1	.1	< .1	< .1	< .1	.1
)2	.70	1.27	.88	.23	.20	.83
)5	.16	.20	.22	.05	.04	.12
)	.14	.19	.23	.04	.03	.11
2	.5	2.7	.9	.8	1.0	.1
3	.000	.200	.070	.070	.000	.025
TAL	98.4	99.2	97.8	98.6	98.5	98.3
	5.5	51.0	200.	5.5	6.0	80.0
	< .5	.5	.5	< .5	< .5	.5
	< 2.	2.	< 2.	< 2.	< 2.	9.
	48.0	100.	38.0	31.0	12.0	54.0
	20.	40.	10.	20.	20.	10.
	4.	4.	4.	6.	6.	< 2.
	100.	90.	40.	90.	70.	100.
	2.	4.	4.	1.	1.	4.
	.3	.9	.9	< .2	.4	< .2
	160.	270.	270.	21.	17.	310.
	92.	48.	65.	44.	34.	103.
	3.0	2.0	4.0	3.5	4.0	.5
	12.0	33.0	15.0	3.0	2.5	17.0
	21.0	20.0	16.0	3.0	4.0	31.0

3 greywacke (9a), (Good), hornblende-bearing plag-rich greywacke, minor shearing and fracturing, epidote, qtz, calcite veins, foliated

), 123 greywacke (9a), (Good), hornblende-bearing greywacke, fractured, sheared, very calcite-rich, unfoliated

), 129 greywacke (9a), (Rabbit's), mg qtz with porphyroblastic, poikioblastic amphiboles, minor foliation

. granodiorite dike (17), (Good), cataclastic plag, microcline and qtz crystoblasts in a fg schistose, matrix of qtz, plag and musc, flaser structure, sheared

2 granodiorite dike (17), (Good), cataclastic, plag, microcline and qtz crystoblasts (to 3mm) in a fg matrix of plag, qtz and musc, flaser structure, qtz veins

3, 128 dacitic lapilli tuff (5b), (Good), fg qtz and plag blasts in a matrix of plag, qtz and musc, poikioblastic hornblende occurs in more mafic lapilli fragments

SAMPLE	054	055	056	057	058	059
SiO_2	55.2	56.0	49.9	50.5	49.3	47.8
Al_2O_3	13.7	14.2	14.3	14.6	19.5	18.0
Fe_2O_3	3.35	3.34	2.80	2.99	2.65	2.76
FeO	8.5	8.6	8.1	8.2	5.1	9.3
CaO	5.97	4.50	9.16	9.37	9.48	10.6
MgO	4.26	2.54	6.08	5.77	5.78	4.25
Na_2O	3.63	2.59	2.93	3.06	3.57	2.60
K_2O	.43	1.49	.65	.37	.29	.28
H_2O^+	1.1	2.5	.8	.8	1.5	.9
H_2O^-	< .1	.1	< .1	< .1	< .1	< .1
TiO_2	1.43	.97	1.05	1.01	.57	.93
P_2O_5	.31	.29	.21	.21	.09	.04
MnO	.19	.17	.21	.20	.13	.21
CO_2	< .1	1.5	1.4	.9	.5	.2
SO_3	.065	.220	.045	.015	.015	.010
TOTAL	98.2	99.0	97.7	97.6	98.5	97.9
Cu	61.0	130.	150.	48.	110.	96.0
Ag	< .5	< .5	.5	.5	.5	< .5
Au	<2.	3.	15.	3.	8.	6.
Zn	35.0	140.	40.	34.0	25.0	19.0
Y	20.	30.	20.	20.	10.	20.
Pb	<2.	<2.	6.	6.	4.	4.
Zr	90.	80.	30.	70.	20.	10.
As	1.	3.	4.	4.	1.	13.
Sb	.7	.7	.7	.9	1.3	.6
V	190.	110.	330.	370.	190.	410.
Cr	34.	27.	55.	48.	34.	27.
Mo	2.5	.5	4.5	4.5	3.0	2.0
Co	10.0	22.0	14.0	8.5	12.0	15.0
Ni	3.0	< .5	18.0	11.0	17.0	2.0

054 massive andesite (4a), (Tornado), recrystallized, fg plag microlites in a vfg recrystallized matrix of plag and qtz, minor shearing, "relict" opaques, schistose

055 dacitic tuff (5b), (Tornado), vfg slightly schistose, contains qtz, plag(?) and penninite

056 massive andesite (4a), (Tornado-Mirage), completely recrystallized, unfoliated, qtz and calcite veins, "relict" opaques

057 greywacke (9a), (Tornado-Mirage), amphibole-bearing greywacke, unfoliated

058 mafic tuff (4f), (Tornado-Mirage), recrystallized plag phenocrysts in recrystallized matrix, unfoliated

059 basalt check

SAMPLE	060	061	062	063	064	065
SiO_2	51.5	61.1	51.8	53.4	50.6	54.3
Al_2O_3	12.9	15.8	13.7	16.1	13.3	13.9
Fe_2O_3	3.78	2.89	3.90	2.74	3.51	3.84
FeO	6.4	3.4	9.9	5.9	7.1	8.6
CaO	10.6	6.04	8.47	8.08	10.3	6.21
MgO	8.68	2.97	4.61	6.13	8.09	4.43
Na_2O	2.41	3.68	3.03	2.97	2.37	3.52
K_2O	.40	1.39	.39	.29	.31	.35
H_2O^+	.7	.6	1.0	1.3	1.0	1.3
H_2O^-	< .1	< .1	< .1	.1	.1	.1
TiO_2	.67	.60	1.34	.74	.71	1.50
P_2O_5	.13	.12	.18	.09	.13	.30
MnO	.21	.10	.23	.18	.21	.19
CO_2	< .1	.2	.5	.2	.3	< .1
SO_3	.020	.010	.015	.000	.020	.030
TOTAL	98.5	99.0	99.1	98.2	98.0	98.6
Cu	17.0	24.0	150.	12.0	42.0	36.0
Ag	< .5	< .5	< .5	< .5	< .5	< .5
Au	2.	2.	24.	<2.	2.	3.
Zn	17.0	64.0	42.0	28.0	20.0	37.0
'	20.	10.	20.	10.	0.	40.
Pb	<2.	2.	2.	2.	2.	°2.
Cr	30.	110.	70.	30.	40.	90.
As	2.	<1.	3.	3.	4.	1.
Sb	1.1	.2	.4	.7	.9	.8
'	300.	150.	430.	260.	320.	390.
:r	202.	68.	31.	75.	171.	34.
Mo	1.5	1.5	3.0	2.5	3.0	2.0
Co	6.5	17.0	8.0	8.5	7.5	10.0
Ni	8.0	28.0	3.5	11.0	9.0	2.0

060 porphyritic basalt (3b), (Rabbit's), glomerophyric hornblende pseudomorphs after pyroxene phenocrysts in a mirolitic groundmass, foliated

061, 073 laminated siltstone (9b), (Rabbit's), laminations defined by hornblende content, a few fg plag microclasts

062 massive andesite (2a), (Rabbit's), no primary texture preserved, qtz veins, unfoliated

063 mafic tuff (4f), (Rabbit's), minor recrystallized plag phenocrysts in a recrystallized matrix, foliated

064 porphyritic basalt (3b), (Rabbit's), hornblende pseudomorphs after pyroxene phenocrysts, foliated, calcite and qtz veins

065 int tuff (5a), (Tornado), completely recrystallized, foliated, calcite and qtz veins

SAMPLE	066	067	069	070	071	072
SiO2	51.2	53.5	49.9	52.2	49.4	48.0
Al2O3	13.9	17.8	18.6	13.8	16.4	18.0
Fe2O3	4.33	4.53	2.70	2.84	4.13	2.74
FeO	9.6	5.1	7.2	10.4	6.9	9.5
CaO	6.56	6.27	7.06	7.66	8.37	10.7
MgO	3.93	3.84	5.56	4.71	6.21	4.22
Na2O	4.45	3.13	3.09	3.22	2.78	2.66
K2O	.56	1.34	1.79	.23	1.75	.27
$H2O^+$	1.1	1.2	1.4	1.0	.9	.9
$H2O^-$	< .1	< .1	< .1	< .1	< .1	< .1
TiO2	1.63	.83	.81	1.48	.88	.92
P2O5	.25	.11	.12	.20	.25	.04
MnO	.22	.14	.17	.22	.21	.21
CO2	< .1	< .1	< .1	.2	.5	.2
SO3	.085	.335	.190	.080	.085	.000
TOTAL	97.9	98.2	98.7	98.3	98.8	98.4
Cu	32.0	170.	80.	71.0	150.	91.0
Ag	< .5	.5	.5	< .5	1.0	< .5
Au	<2.	14.	2.	2.	3.	11.
Zn	30.0	72.0	63.0	20.0	78.0	18.0
Y	30.	10.	20.	40.	10.	0.
Pb	<2.	<2.	<2.	2.	4.	4.
Zr	70.	40.	40.	70.	50.	0.
As	2.	4.	3.	1.	2.	14.
Sb	2.1	1.0	.5	.4	.3	.6
V	410.	320.	280.	480.	340.	440.
Cr	34.	41.	44.	34.	48.	24.
Mo	4.0	< .5	1.0	3.0	2.0	3.0
Co	9.0	28.0	23.0	4.0	23.0	14.0
Ni	3.5	6.0	13.0	4.0	19.0	2.0

066 massive andesite (2a), (Rabbit's), completely recrystallized, unfoliated
067 massive siltstone (9b), (Rabbit's), vfg, schistose
069 mafic tuff (4f), (Rabbit's), completely recrystallized, qtz veins, foliated
070 massive andesite (2a), (Rabbit's), completely recrystallized, foliated
071 greywacke (9a), (Rabbit's), hornblende-bearing, musc-rich greywacke, qtz veins, foliated
072 basalt check

AMPLE	073	074	075	076	077	078
iO2	60.1	52.3	49.4	56.9	50.5	52.1
1203	15.9	17.1	13.8	14.1	16.4	13.6
e2O3	2.40	3.95	3.02	2.33	6.54	3.25
eO	3.6	4.9	9.7	4.3	3.2	11.2
aO	6.24	8.84	9.47	9.13	11.8	6.64
gO	2.75	4.35	4.33	2.37	5.57	4.1
a2O	3.91	3.77	2.89	3.87	1.90	3.67
2O	1.38	1.16	.50	.88	.72	.16
$2O^+$	.5	1.0	1.0	.7	.6	.8
$2O^-$	< .1	< .1	.1	.1	< .1	< .1
iO2	.59	.78	1.61	.99	.82	1.77
2O5	.12	.25	.15	.23	.19	.19
nO	.10	.18	.23	.14	.22	.21
O2	.4	.2	1.5	2.2	< .1	.2
O3	.000	.000	.020	.005	.000	.624
OTAL	98.1	98.8	97.7	98.2	98.6	98.6
u	19.0	32.0	71.0	29.0	2.0	80.0
g	< .5	< .5	< .5	.5	.5	< .5
u	<2.	4.	4.	<2.	<2.	2.
n	61.0	30.0	31.0	55.0	23.0	23.0
	20.	20.	20.	20.	20.	50.
b	2.	4.	6.	6.	4.	2.
r	100.	80.	70.	70.	40.	120.
s	1.	5.	<1.	7.	5.	6.
b	.9	.4	.9	1.4	1.5	.6
	150.	210.	480.	290.	250.	380.
r	62.	75.	34.	41.	137.	31.
o	3.0	5.0	4.0	5.0	3.0	2.0
o	17.0	8.0	11.0	9.0	8.0	15.0
i	28.0	14.0	3.0	5.0	14.0	4.0

73, 061 laminated siltstone (9b), (Rabbit's), laminations defined by hornblende content, a few fg plag microclasts

74, 096 greywacke (9a), (Rabbit's), actinolite-bearing greywacke, unfoliated

75 int tuff (4g), (Rabbit's), layers of porphyroblastic, recrystallized plag and hornblende

76 porphyritic andesite (3c), (Rabbit's), recrystallized plag phenocrysts in a fg groundmass, calcite and qtz veins, foliated

77 greywacke (9a), (Rabbit's), hornblende-bearing greywacke, qtz veins, minor shearing, unfoliated

78 int tuff (4g), (Rabbit's), mg, poikioblastic hornblende prophyroblasts in a fg gneissic matrix of hornblende and plag

SAMPLE	079	080	081	082	083	084
SiO_2	48.8	47.9	47.5	50.6	63.1	50.6
Al_2O_3	16.5	13.9	17.9	13.5	13.8	12.0
Fe_2O_3	3.29	2.91	2.31	3.50	2.13	3.84
FeO	7.3	11.6	9.8	9.0	6.6	6.8
CaO	7.66	9.77	10.6	10.3	4.91	13.0
MgO	7.16	5.77	4.19	3.88	1.67	1.79
Na_2O	2.32	2.74	2.71	2.68	3.92	2.40
K_2O	2.39	.39	.28	.26	.15	.40
H_2O^+	1.2	.3	.4	.9	1.0	.9
H_2O^-	< .1	.1	< .1	< .1	< .1	< .1
TiO_2	.68	1.51	.91	1.42	.75	1.10
P_2O_5	.16	.17	.04	.23	.17	.11
MnO	.19	.24	.21	.22	.15	.22
CO_2	< .1	.4	.3	1.4	.3	4.9
SO_3	.240	.230	.010	.055	.155	.130
TOTAL	98.0	97.9	97.2	98.0	98.9	98.3
Cu	98.0	110.	110.	34.0	47.0	49.0
Ag	< .5	< .5	< .5	< .5	< .5	.5
Au	<2.	<2.	7.	2.	<2.	<2.
Zn	72.0	18.0	18.0	18.0	54.0	17.0
Y	0.	30.	0.	30.	50.	30.
Pb	4.	4.	4.	6.	4.	11.
Zr	30.	50.	10.	60.	160.	60.
As	2.	2.	13.	3.	3.	3.
Sb	.3	.2	.8	.9	1.0	.5
V	270.	400.	340.	330.	48.	450.
Cr	51.	34.	24.	38.	38.	27.
Mo	4.0	3.0	3.0	5.0	2.0	6.0
Co	35.0	11.0	14.0	6.0	6.0	9.0
Ni	24.0	12.0	1.0	10.0	< .5	3.0

079, 097 greywacke (9a), (Rabbit's), hornblende-bearing greywacke, foliated

080 massive aphyric basalt (2b), (Rabbit's), no primary texture preserved, "relict" opaques

081 basalt check

082 amygdaloidal porphyritic basalt (4e), (Rabbit's), polymineralic amygdales, hornblende pseudomorphs after pyroxene phenocrysts, qtz veins, foliated

083 greywacke (9a), (Rabbit's), hornblende-bearing, plag-rich greywacke, unfoliated

084 amygdaloidal porphyritic basalt (4e), (Rabbit's), polymineralic amygdales, hornblende pseudomorphs after pyroxene phenocrysts in a microlitic groundmass, "relict" opaques, fractured, unfoliated

SAMPLE	085	086	087	088	089	090
SiO2	50.6	69.4	52.7	67.3	47.8	51.1
Al2O3	13.4	15.0	17.4	16.5	16.5	14.6
Fe2O3	4.16	1.52	2.53	1.33	2.21	2.73
FeO	9.3	.5	4.5	1.6	6.2	8.7
CaO	9.30	2.37	7.74	3.06	10.3	9.31
MgO	4.12	.53	3.98	1.15	10.3	5.91
Na2O	2.80	5.05	4.18	4.44	1.92	2.98
K2O	.27	2.03	1.96	2.19	.56	.35
$H2O^+$	.9	.5	1.4	.8	1.5	.6
$H2O^-$	< .1	.1	.1	.1	.1	< .1
TiO2	1.56	.25	.84	.32	.13	.90
P2O5	.17	.06	.21	.08	.01	.15
MnO	.24	.04	.11	.06	.16	.20
CO2	.9	.6	1.3	.3	.3	.3
SO3	.060	.000	.260	.000	.000	.055
TOTAL	97.8	98.0	99.2	99.2	98.0	97.9
Cu	71.0	6.0	85.0	4.0	2.0	150.
Ag	< .5	< .5	.5	< .5	< .5	< .5
Au	2.	71.	<2.	<2.	80.	6.
Zn	27.0	19.0	35.0	50.0	11.0	19.0
Y	40.	0.	10.	10.	10.	20.
Pb	5.	4.	6.	4.	4.	4.
Zr	100.	80.	50.	90.	0.	30.
As	1.	3.	9.	5.	29.	4.
Sb	1.3	.4	2.0	.5	1.2	1.6
V	330.	24.	190.	23.	180.	310.
Cr	34.	44.	62.	27.	212.	44.
Mo	4.0	3.0	3.0	2.0	3.0	3.0
Co	10.0	2.0	17.0	7.0	21.0	8.0
Ni	9.0	4.0	45.0	7.0	31.0	11.0

085 massive andesite (2a), (Rabbit's), completely recrystallized, foliated

086 granodiorite dike (17), (Rabbit's), cataclastic plag and qtz augens in fg matrix of plag, qtz and musc, calcite veins

087, 105 greywacke (9a), (Rabbit's), actinolite-bearing greywacke, calcite, qtz, plag veins, foliated

088 granodiorite (16a), (Rabbit's), porphyritic, anhedral zoned and myrmekitic plag and microcline, fg qtz

089 subvolcanic intrusion (1), (Rabbit's), cg actinolite and poikioblastic tourmaline (schorl) with minor qtz

090 massive aphyric basalt (4b), (Rabbit's), no primary texture preserved, "relict" opaques, unfoliated, fractured

MPLE	091	092	093	094	095	096
O2	51.0	44.9	69.1	49.0	52.3	50.9
2O3	14.7	10.7	15.5	11.3	17.0	17.5
2O3	2.78	2.27	1.26	1.83	4.50	5.43
O	11.0	7.5	.5	7.8	5.4	4.8
O	6.25	13.5	2.51	9.97	7.21	8.65
O	4.40	12.3	.67	12.2	4.53	4.76
2O	4.58	1.75	4.74	1.90	2.33	3.91
O	.14	.29	2.67	.81	2.74	1.11
O^+	1.0	1.4	.3	1.4	1.0	1.0
O^-	< .1	< .1	< .1	.1	< .1	< .1
O2	1.51	.64	.21	.95	.78	.86
O5	.19	.16	.05	.22	.27	.26
O	.23	.22	.04	.20	.16	.20
2	.3	2.2	.4	.3	< .1	.1
3	.345	.000	.000	.000	.005	.000
TAL	98.5	97.9	98.0	98.0	98.3	99.6
	72.0	21.0	6.0	1.0	190.	39.0
	< .5	< .5	< .5	< .5	.5	< .5
	2.	<2.	28.	2.	<2.	6.
	22.0	16.0	34.0	22.0	100.	23.0
	40.	0.	0.	10.	30.	30.
	<2.	6.	4.	4.	°2.	4.
	110.	20.	80.	60.	50.	80.
	1.	<1.	3.	3.	4.	2.
	.4	.8	.5	.5	.6	.9
	330.	220.	23.	220.	240.	250.
	34.	414.	48.	404.	62.	68.
	2.0	5.0	2.0	2.0	< .5	3.0
	14.0	8.0	3.0	12.0	27.0	6.0
	5.0	31.0	4.0	28.0	17.0	11.0

1 int tuff (4g), (Rabbit's), mg poikioblastic hornblende porphyroblasts in a vfg-fg gneissic plag matrix

2 porphyritic basalt (3b), (Rabbit's), amphibole pseudomorphs after pyroxene phenocrysts, minor shearing, foliated

3 granodiorite dike (17), (Rabbit's), cataclastic plag and qtz crystoblasts in a fg matrix of plag and qtz, very sheared, qtz veins

4 porphyritic basalt (3b), (Rabbit's), completely recrystallized, sheared, unfoliated

5 massive siltstone (9b), (Rabbit's), vfg with minor hornblende (4%), schistose

6, 074 greywacke (9a), (Rabbit's), actinolite-bearing greywacke, unfoliated

MPLE	097	098	099	100	101	102
O2	49.4	49.0	46.6	63.5	68.2	53.5
2O3	15.9	15.3	9.64	16.4	15.8	15.9
2O3	3.77	5.51	2.18	1.47	1.31	5.37
O	6.6	5.3	4.4	4.4	.5	4.8
O	8.33	13.0	17.4	3.44	2.99	7.90
O	6.86	5.56	7.71	1.60	.67	5.10
2O	2.29	1.16	2.42	3.91	4.12	2.62
O	2.02	.41	.55	2.17	3.10	1.46
O^+	1.0	.8	.6	1.3	.4	.8
O^-	< .1	< .1	< .1	.1	< .1	< .1
O2	.66	.69	.30	.75	.24	.79
O5	.16	.12	.09	.28	.06	.17
O	.19	.20	.16	.13	.04	.17
2	.1	.1	5.8	.3	.6	.2
3	.245	.005	.000	.000	.000	.000
TAL	97.6	97.2	97.9	99.8	98.1	98.8
	99.0	51.0	4.0	27.0	3.0	100.
	.5	< .5	< .5	.5	< .5	.5
	2.	<2.	5.	2.	<2.	5.
	60.0	18.0	4.0	110.	27.0	66.0
	0.	0.	0.	0.	0.	0.
	2.	4.	13.	4.	4.	°2.
	10.	30.	10.	150.	70.	60.
	5.	16.	16.	2.	3.	3.
	2.3	1.3	1.8	.4	.5	.5
	240.	320.	140.	69.	26.	240.
	51.	96.	363.	27.	44.	181.
	5.0	3.0	7.0	< .5	3.0	.5
	32.0	9.0	8.0	7.0	3.0	24.0
	23.0	9.0	21.0	< .5	5.0	55.0

97, 079 greywacke (9a), (Rabbit's), hornblende-bearing greywacke, foliated

98 greywacke (9a), (Rabbit's), hornblende-bearing greywacke, epidote-rich, unfoliated

99 porphritic basalt (3b), (Rabbit's), glomerophyric hornblende pseudomorphs after pyroxene phenocrysts, well foliated, calcite veins

00 dacitic lapilli(?) tuff (6a), (Rabbit's), fg plag, musc, qtz in a vfg, schistose crenulated and sheared matrix of plag, musc and qtz, some plag-rich bands are possible lapilli(?)

01 granodiorite dike (17), (Rabbit's), cataclastic plag, microcline and qtz crystoblasts in a fg matrix of plag, microcline, qtz and bio, gneissic, flaser structure calcite and qtz veins

02 greywacke (9a), (Rabbit's), hornblende-bearing greywacke, minor qtz veins, foliated

'LE	103	104	105	106	107	108
!	47.3	64.0	53.9	53.1	52.2	48.3
)3	15.9	15.6	18.0	14.9	16.0	17.9
)3	2.12	3.16	2.30	3.98	2.37	2.45
	8.8	2.5	4.2	5.6	5.4	9.4
	11.8	4.39	7.03	9.20	8.54	10.4
	5.50	2.13	3.37	5.00	5.78	4.12
)	2.52	3.75	4.56	2.73	4.08	2.63
	.23	1.60	2.21	.85	.85	.31
-	.6	.4	1.0	.8	.8	.5
-	.1	.1	< .1	.1	.1	.1
!	1.33	.57	.76	.74	.90	.93
;	.10	.10	.21	.16	.21	.04
	.17	.09	.10	.19	.14	.21
	1.0	.4	1.3	.6	.6	.2
	.000	.000	.315	.000	.000	.000
\L	97.5	98.8	99.3	97.9	97.9	97.5
	50.0	26.0	150.	27.0	200.	94.0
	< .5	.5	.5	< .5	< .5	< .5
	<2.	8.	2.	19.	5.	8.
	11.	70.	40.	36.0	35.0	19.0
	30.	10.	10.	30.	20.	0.
	4.	2.	4.	4.	4.	4.
	70.	100.	60.	60.	60.	0.
	10.	2.	8.	4.	18.	13.
	.9	< .2	1.6	.8	1.6	1.0
	380.	120.	170.	230.	270.	350.
	62.	58.	44.	75.	92.	27.
	3.0	1.0	3.0	5.0	2.0	3.0
	15.0	17.0	17.0	12.0	16.0	14.0
	10.0	19.0	36.0	13.0	17.0	2.0

porphyritic basalt (4e), (Rabbit's), hornblend pseudomorphs after pyroxene phenocrysts, "relict" opaques, unfoliated

laminated siltstone (9b), (Rabbit's), laminations defined by more plag-rich zones, poorly foliated

, 087 greywacke (9a), (Rabbit's), actinolite -bearing greywacke, calcite, qtz, plag veins, foliated

greywacke (9a), (Rabbit's), hornblende-bearing greywacke, unfoliated

porphyritic breccia (3c), (Rabbit's), hornblende pseudomorphs after pyroxene phenocrysts, well foliated, sheared

basalt check

SAMPLE	109	110	111A	111B	112	113
SiO2	70.0	46.6	55.2	56.5	60.8	57.5
Al2O3	15.7	10.3	16.2	15.9	15.7	16.7
Fe2O3	1.48	1.87	2.43	2.37	1.76	3.39
FeO	.3	8.4	6.4	6.6	6.4	6.4
CaO	1.66	9.82	5.63	4.89	5.11	3.49
MgO	.54	15.6	3.62	3.94	1.86	3.09
Na2O	4.73	.83	2.31	2.22	3.17	3.80
K2O	2.51	.32	1.38	1.52	1.63	.33
H_2O^+	.3	2.8	2.1	2.2	.9	2.4
H_2O^-	.2	.1	.3	.2	.1	.2
TiO2	.24	.62	.66	.68	.74	.96
P2O5	.05	.18	.07	.08	.16	.14
MnO	.02	.25	.14	.12	.13	.12
CO2	.1	.3	1.0	1.2	.7	.7
SO3	.000	.000	.100	.010	.799	.000
TOTAL	97.8	98.0	97.5	98.4	99.9	99.2
Cu	6.0	18.0	12.0	5.0	89.0	180.
Ag	< .5	< .5	.5	.5	.5	.5
Au	13.	72.	<2.	4.	32.	<2.
Zn	30.0	34.0	85.0	84.0	83.0	95.0
Y	10.	0.	20.	0.	30.	20.
Pb	<2.	4.	6.	6.	4.	<2.
Zr	70.	20.	80.	70.	100.	90.
As	2.	350.	3.	7.	6.	4.
Sb	.7	1.1	.4	.8	.4	.7
V	28.	240.	200.	240.	89.	140.
Cr	48.	790.	44.	51.	44.	27.
Mo	< .5	2.0	2.0	1.0	1.0	< .5
Co	3.0	50.0	17.0	23.0	14.0	26.0
Ni	5.0	260.	< .5	2.0	< .5	< .5

109, 125 granodiorite dike (17), (Good), cataclastic microcline, qtz, albite and oligoclase crystoblasts in a fg matrix of qtz, plag and musc, flaser structure, schistose, sheared

110 subvolcanic intrusive (1), (Good), recrystallized diabase dike, poor foliation

111A,111B dacitic tuff (5b), (Tornado), qtz, bio and chlorite, good foliation, calcite veins

111B,111A dacitic tuff (5b), (Tornado), qtz, bio and chlorite, good foliation, calcite veins

112 siltstone (9b), (Good), fg qtz and musc, foliated

113 amygdaloidal andesite (4c), (Mirage), recrystallized plag phenocrysts, polymineralic amygdales, unfoliated, minor sheared

SAMPLE	114	115	116	117	118	119
SiO2	53.8	50.8	46.3	53.9	51.6	55.1
Al2O3	15.8	14.1	15.8	14.9	17.1	16.0
Fe2O3	3.58	2.19	2.19	3.44	5.71	4.58
FeO	5.0	10.0	8.2	5.6	5.3	4.8
CaO	8.65	9.01	12.3	8.50	8.44	6.44
MgO	4.73	6.17	4.55	4.70	3.49	5.18
Na2O	2.99	1.88	2.96	3.24	2.86	3.70
K2O	1.49	.23	.20	.95	.96	.36
$H2O^+$	.9	1.4	1.0	.8	.8	1.1
$H2O^-$	.2	.1	.2	.2	.2	.3
TiO2	.72	.94	1.19	.73	.97	.77
P2O5	.15	.08	.08	.15	.17	.19
MnO	.16	.20	.16	.16	.19	.15
CO2	.4	.6	2.8	.3	.1	.5
SO3	.514	.055	.095	.000	.145	.010
TOTAL	99.1	97.8	.0	97.6	98.0	99.2
Cu	42.0	64.0	51.0	13.0	98.0	110.
Ag	< .5	< .5	< .5	< .5	.5	.5
Au	2.	8.	10.	<2.	5.	93.
Zn	47.0	27.0	16.0	37.0	59.0	45.0
Y	10.	30.	10.	0.	10.	10.
Pb	<2.	4.	8.	4.	2.	4.
Zr	80.	40.	50.	80.	70.	80.
As	4.	3.	26.	1.	5.	6.
Sb	1.2	.4	.6	1.0	1.0	.7
V	230.	340.	350.	220.	290.	210.
Cr	82.	44.	99.	68.	58.	123.
Mo	3.0	3.0	6.0	3.0	2.0	2.0
Co	18.0	12.0	25.0	13.0	19.0	15.0
Ni	17.0	6.0	39.0	13.0	4.0	27.0

114 porphyritic andesite (3a), (Tornado), recrystallized plag phenocrysts, qtz and calcite veins, foliated

115 greywacke (9a), (Good), hornblende-bearing greywacke, unfoliated

116 massive aphyric basalt (4b), (Good), no primary texture preserved, foliated

117 porphyritic amygdaloidal andesite (3a), (Luck), recrystallized plag phenocrysts in fg matrix, polymineralic amygdales, qtz, calcite veins, foliated

118 greywacke (9a), (Good), hornblende-bearing, epidote rich, greywacke, fractured, foliated

119, 133 greywacke (9a), (Good), amphibole-bearing greywacke, unfoliated

SAMPLE	120	121	122	123	124	125
SiO2	47.6	52.4	63.8	53.3	48.3	70.5
Al2O3	15.1	14.3	13.8	15.6	18.0	15.5
Fe2O3	2.58	3.36	1.88	1.97	2.75	1.26
FeO	11.9	10.2	2.3	7.1	9.4	.6
CaO	8.24	8.54	5.80	5.75	10.7	1.79
MgO	6.31	3.95	2.15	4.07	4.20	.52
Na2O	3.11	2.60	4.22	2.49	2.56	4.64
K2O	.19	.26	1.63	2.37	.27	2.40
$H2O^+$	.8	.8	.8	2.4	1.0	.5
$H2O^-$	.2	.1	.1	.1	.1	.1
TiO2	1.77	1.47	.34	1.09	.95	.22
P2O5	.14	.26	.06	.21	.04	.05
MnO	.23	.21	.12	.14	.21	.05
CO2	.1	.2	2.5	2.2	.3	.2
SO3	.005	.175	.000	.125	.080	.095
TOTAL	98.3	98.8	99.5	98.9	98.9	98.4
Cu	14.0	170.	18.0	56.0	91.0	4.0
Ag	< .5	< .5	.5	.5	< .5	< .5
Au	3.	7.	10.	<2.	16.	3.
Zn	16.0	21.0	52.0	88.0	17.0	29.0
Y	30.	30.	10.	20.	10.	0.
Pb	2.	2.	10.	4.	4.	4.
Zr	80.	90.	40.	120.	10.	70.
As	34.	1.	2.	4.	11.	4.
Sb	.9	.9	.3	.4	.5	.7
V	480.	480.	89.	250.	370.	28.
Cr	51.	34.	51.	44.	24.	44.
Mo	2.0	2.0	3.0	1.0	2.0	1.0
Co	27.0	10.0	16.0	26.0	14.0	3.0
Ni	10.0	5.0	20.0	37.0	2.0	5.0

120 massive aphyric basalt (4b), (Good), no primary texture preserved, foliated

121 massive basalt (2b), (Tornado), recrystallized microlitic plag, "relict" opaques, unfoliated

122 siltstone (9b), (Tornado), vfg, qtz veins, sheared

123, 049 greywacke (9a), (Good), hornblende-bearing greywacke, fractured and sheared, very calcite rich, unfoliated

124 basalt check

125, 109 grandodiorite dike (17), (Good), cataclastic microcline, qtz, albite and oligoclase crystoblasts in a fg matrix of qtz, plag and musc, flaser structure, schistose, sheared

SAMPLE	126	127	128	129	130	131
SiO2	53.9	52.6	60.1	49.4	54.0	55.6
Al2O3	18.9	17.3	14.4	15.2	14.1	17.3
Fe2O3	2.63	3.67	3.46	4.65	5.67	3.20
FeO	4.9	6.6	4.1	6.7	4.8	4.4
CaO	4.29	6.21	6.29	7.37	8.58	3.08
MgO	2.82	2.34	3.10	6.43	4.77	4.53
Na2O	1.51	3.29	3.30	2.64	2.69	1.70
K2O	4.58	.49	1.57	.82	.69	4.79
$H2O^+$	2.1	2.1	.6	2.0	.9	1.0
$H2O^-$	.1	< .1	.1	.2	.3	.2
TiO2	.61	1.07	.77	.88	.72	.71
P2O5	.08	.09	.12	.21	.14	.19
MnO	.14	.14	.10	.20	.19	.09
CO2	2.2	1.7	.5	1.3	1.7	.1
SO3	.040	.015	.000	.000	.055	.000
TOTAL	98.8	97.7	98.5	98.0	99.3	96.9
Cu	25.0	37.0	95.0	44.0	5.0	4.0
Ag	.5	< .5	.5	.5	.5	.5
Au	5.	<2.	<2.	9.	93.	<2.
Zn	100.	92.0	49.0	68.0	34.0	130.
Y	20.	30.	30.	20.	10.	10.
Pb	6.	2.	4.	6.	6.	<2.
Zr	70.	70.	120.	50.	40.	110.
As	2.	3.	6.	4.	2.	2.
Sb	.9	.4	.2	1.0	.7	< .2
V	230.	260.	180.	280.	220.	120.
Cr	31.	24.	96.	82.	147.	68.
Mo	3.0	1.0	2.0	3.0	4.0	< .5
Co	19.0	17.0	15.0	22.0	15.0	28.0
Ni	5.0	< .5	31.0	27.0	17.0	48.0

126 int tuff (5a), (Mirage), cataclastic fg qtz and plag in vfg matrix of qtz, plag, musc, qtz, and calcite veins, flaser structrue, sheared

127 altered mafic tuff (4fa), (Tornado), very schistose, contains plag, qtz and penninite, phyllonitic and sheared

128, 053 dacitic lapilli tuff, (5b), (Good), fg porphyroblastic qtz and plag in a matrix of plag, qtz and musc, porphyroblastic and poikioblastic hornblende occurs in more mafic lapilli fragments

129, 050 greywacke (9a), (Good), mg qtz with porphyroblastic, poikioblastic amphibole, minor foliation

130 greywacke (9a), (Good), amphibole-bearing greywacke, calcite-rich, foliated

131 massive siltstone (9b), (Good), vfg, a few garnets, foliated

AMPLE	132	133	134	135	136	137
iO2	51.7	53.3	61.7	56.8	49.3	48.0
1203	14.7	15.5	15.0	16.8	13.6	17.8
e2O3	2.72	4.74	1.59	2.94	2.50	2.44
eO	9.7	5.0	4.8	6.8	11.7	9.5
aO	8.61	6.63	5.65	5.60	8.79	10.4
gO	4.34	5.41	2.82	3.17	5.86	4.17
a2O	2.45	3.59	4.26	3.23	2.39	2.64
2O	.38	.36	.60	.34	.33	.28
$2O^{+}$	1.3	1.3	1.6	2.3	1.9	.9
$2O^{-}$	.2	.2	.1	.2	< .1	.2
iO2	1.47	.77	.64	.62	1.57	.92
2O5	.32	.17	.14	.06	.12	.04
nO	.18	.15	.12	.15	.21	.21
O2	.7	.5	.7	.4	1.6	.3
O3	.135	.060	.055	.090	.000	.000
OTAL	98.9	97.7	99.8	99.5	99.9	97.8
u	68.0	110.	40.0	130.	1.0	100.
g	< .5	.5	< .5	1.0	.5	< .5
u	<2.	95.	<2.	15.	8.	6.
n	34.0	46.0	31.0	64.0	38.0	19.0
	30.	10.	20.	0.	20.	0.
b	4.	4.	4.	<2.	4.	4.
r	100.	70.	100.	0.	70.	10.
s	7.	5.	3.	5.	17.	17.
b	.5	.4	.8	.9	.8	.8
	400.	220.	170.	210.	390.	340.
r	27.	116.	58.	34.	48.	24.
ɔ	4.0	2.0	3.0	< .5	3.0	3.0
ɔ	13.0	18.0	8.0	18.0	18.0	15.0
i	8.0	30.0	17.0	1.0	8.0	2.0

32 greywacke (9a), (Good), fg qtz with porphroblastic and poikioblastic amphiboles, foliated

33, 119 greywacke (9a), (Good), amphibole-bearing greywacke, unfoliated

34 laminated siltstone (9b), (Good), laminations defined by amphibole-rich layers

35 laminated siltstone (9b), (Good), laminations defined by hornblende-rich layers, crenulated, foliated

36 greywacke (9a), (Good), hornblende-bearing greywacke, unfoliated

37 basalt check

;AMPLE	138	139	140	141	142	143
;iO2	58.2	69.3	48.1	48.3	49.7	43.6
\l2O3	15.8	16.2	13.1	12.9	14.5	18.4
'e2O3	3.42	1.45	2.33	2.35	4.61	2.89
'eO	4.4	.1	10.5	11.2	6.2	7.3
:aO	6.14	1.25	9.70	9.91	9.96	9.01
1gO	2.28	.49	5.60	5.04	7.06	4.19
Ja2O	3.65	5.93	2.74	2.28	2.95	2.97
:2O	2.28	2.07	1.03	.34	.32	2.42
I2O+	.7	.9	1.1	1.2	.8	1.2
I2O-	.1	< .1	< .1	.2	< .1	.3
:iO2	.77	.24	1.32	1.55	.84	.82
'2O5	.26	.05	.09	.13	.19	.06
InO	.16	.03	.21	.23	.21	.16
:O2	1.2	.4	3.2	2.3	.4	4.3
;O3	.005	.000	.000	.040	.000	.000
:OTAL	99.4	98.5	99.1	98.0	97.8	97.6
:u	150.	3.0	4.0	9.0	120.	3.0
\g	< .5	< .5	< .5	1.5	< .5	< .5
\u	<2.	<2.	<2.	<2.	28.	<2.
;n	76.0	16.0	40.0	28.0	20.0	61.0
'	0.	0.	0.	0.	0.	0.
'b	6.	4.	10.	8.	4.	8.
;r	90.	70.	70.	90.	60.	0.
\s	8.	5.	13.	13.	8.	4.
;b	.6	.9	.2	.5	.6	.5
'	130.	20.	330.	390.	220.	300.
:r	48.	38.	58.	38.	106.	99.
lo	6.0	3.0	9.0	8.0	5.0	7.0
:o	16.0	1.0	23.0	14.0	6.0	28.0
li	15.0	< .5	13.0	3.0	11.0	6.0

38 massive siltstone (9b), (Good), vfg, fair foliation

39 granodiorite dike (17), (Good), cataclastic qtz and plag crystoblasts in a fg matrix of qtz, plag, musc and microcline, flaser structure, schistose, sheared

40 greywacke (9a), (Good), amphibole-rich greywacke, foliated

41 greywacke (9a), (Good), amphibole-bearing greywacke, unfoliated

42 greywacke (9a), (Luck), amphibole-bearing greywacke, poorly foliated

43 laminated siltsone (9b), (Tornado), laminations defined by mica-rich layers, very schistose, phyllonitic, calcite veins

SAMPLE	144	145A	145B	146	147	148
SiO_2	52.0	54.5	47.9	46.8	49.7	55.1
Al_2O_3	13.7	13.5	15.9	14.6	15.5	14.6
Fe_2O_3	3.69	3.92	2.42	2.41	2.75	3.48
FeO	10.0	7.9	8.8	8.0	8.5	8.3
CaO	7.29	6.74	9.52	11.5	9.70	7.33
MgO	4.94	4.20	7.59	7.00	6.80	3.01
Na_2O	2.52	3.50	2.73	2.31	3.33	3.82
K_2O	.51	.46	.31	.59	.31	.32
H_2O^+	1.1	.9	1.5	1.4	.8	.6
H_2O^-	< .1	.1	< .1	.1	.1	< .1
TiO_2	1.32	1.51	.75	.68	.80	1.56
P_2O_5	.22	.31	.09	.08	.09	.29
MnO	.21	.20	.17	.19	.18	.21
CO_2	< .1	.1	2.0	2.6	.3	.6
SO_3	.670	.020	.100	.000	.005	.035
TOTAL	98.3	97.9	99.8	98.3	98.9	99.3
Cu	54.0	47.0	86.0	88.0	140.	21.0
Ag	.5	< .5	< .5	< .5	< .5	< .5
Au	<2.	5.	<2.	<2.	<2.	3.
Zn	21.0	24.0	22.0	27.0	12.0	34.0
Y	30.	50.	20.	20.	10.	30.
Pb	2.	2.	4.	8.	4.	6.
Zr	60.	90.	20.	20.	30.	70.
As	3.	3.	4.	5.	3.	2.
Sb	.8	.9	1.0	.5	.8	.3
V	410.	270.	260.	220.	270.	350.
Cr	181.	31.	103.	86.	89.	31.
Mo	4.0	5.0	5.0	8.0	5.0	7.0
Co	4.0	7.0	14.0	12.0	7.0	10.0
Ni	< .5	< .5	42.0	25.0	12.0	8.0

144 amygdaloidal basalt (2d), (Tornado), well foliated, polymineralic amygdales, "relict" opaques, fractured

145A massive andesite (4a), (Tornado), completely recrystallized, unfoliated, "relict" opaques

145B porphyritic gabbro (13), (Good), porphyritic hornblende pseudomorphs with interstitial plag

146 porphyritic gabbro (13), (Good), porphyritic hornblende pseudomorphs with plagioclase

147 massive andesite (2a), (Good), completely recrystallized, unfoliated

148 massive andesite (2a), (Luck), unfoliated

AMPLE	149	150	151	152	153	154
iO2	48.0	51.0	64.9	50.6	65.3	44.1
l2O3	18.9	13.5	17.7	14.2	18.8	11.7
e2O3	2.95	2.41	1.26	2.69	1.89	1.44
eO	6.7	10.7	1.8	10.9	.8	6.7
aO	8.24	7.34	1.52	6.74	.85	8.71
gO	3.85	3.87	.66	3.82	.66	6.48
a2O	3.37	3.24	7.37	3.35	7.08	4.23
2O	.19	1.02	1.31	1.22	1.76	1.99
$2O^+$	2.6	1.1	.5	1.1	.7	.6
$2O^-$	.1	.1	< .1	.1	.1	.1
iO2	.93	1.48	.30	1.51	.32	1.11
2O5	.04	.33	.17	.34	.16	.49
nO	.18	.23	.07	.20	.03	.17
O2	2.5	1.7	.7	1.4	.1	.2
O3	.000	.509	1.673	.664	1.164	.924
OTAL	98.6	98.5	100.0	98.8	99.7	94.0
a	120.	80.0	39.0	58.0	29.0	66.0
g	< .5	.5	2.0	.5	3.0	1.0
a	<2.	45.	920.	26.	1100.	59.
n	70.0	65.0	130.	96.0	220.	120.
	0.	40.	20.	30.	0.	30.
)	6.	6.	200.	8.	130.	33.
:	10.	110.	470.	100.	490.	100.
;	6.	4.	9.	8.	66.	10.
)	4.7	1.1	1.8	.4	3.6	1.8
	360.	370.	36.	470.	42.	200.
	38.	24.	27.	21.	24.	74.
	6.0	7.0	5.0	6.0	1.0	8.0
	30.0	21.0	1.0	27.0	< .5	36.0
	14.0	3.0	< .5	5.0	< .5	69.0

9 greywacke (9a), (Mirage), 7% plag clasts, graded sequence, foliated

0 greywacke (9a), (K-fir), amphibole-bearing greywacke, unfoliated

1 albitite dike (23a), (Central Showing), anhedral plag (An_{32}-82.4%) with musc (13.6%) and minor opaques (3.2%)

2 greywacke (9a), (Central Showing), hornblende bearing greywacke, sheared

3 albitite dike (23a), (Central Showing), anhedral plag (An_{28}-91%) with minor opaques (4.8%) and musc (4.2%), sheared

4, 158 albitite dike (23a), (Central Showing), very xenolithic, plag-rich dike, highly sheared, qtz and calcite veins, foliated

SAMPLE	155	156	157	158	159	160
SiO2	48.1	67.0	44.5	44.6	47.8	41.5
Al2O3	13.6	16.9	11.6	11.4	8.59	10.8
Fe2O3	2.91	2.21	1.70	2.07	5.91	4.01
FeO	8.9	.6	6.6	6.2	3.4	4.2
CaO	7.28	.72	8.51	8.72	10.3	11.1
MgO	4.73	.60	6.98	6.46	4.62	5.45
Na2O	4.80	8.00	4.19	4.29	4.11	5.09
K2O	.72	.98	1.92	1.89	.14	.15
$H2O^+$	.9	.7	.2	< .1	.4	< .1
$H2O^-$	.1	.1	.1	.1	< .1	.1
TiO2	1.24	.27	1.13	1.11	.60	1.03
P2O5	.15	.15	.53	.47	.28	.27
MnO	.21	.03	.17	.19	.18	.20
CO2	4.8	.1	9.9	10.6	12.2	14.4
SO3	.265	.474	.260	.894	5.793	3.421
TOTAL	98.7	98.8	98.3	99.0	104.4	101.8
Cu	38.0	24.0	52.0	74.0	8.0	10.0
Ag	.5	2.0	1.0	1.5	1.0	1.5
Au	5.	460.	26.	150.	6100.	3700.
Zn	62.0	96.0	88.0	120.	60.0	64.0
Y	50.	0.	10.	10.	20.	20.
Pb	12.	120.	31.	35.	55.	24.
Zr	80.	450.	80.	90.	50.	100.
As	12.	10.	7.	8.	120.	70.
Sb	1.5	2.3	4.0	1.2	13.0	20.0
V	280.	30.	220.	220.	120.	190.
Cr	34.	31.	188.	185.	137.	147.
Mo	8.0	11.0	8.0	9.0	21.0	13.0
Co	22.0	< .5	38.0	35.0	28.0	41.0
Ni	10.0	< .5	74.0	70.0	69.0	75.0

155 int tuff (5a), (Central Showing), cataclastic, recrystallized groundmass, sheared

156 albitite dike (23a), (Central Showing), plag-rich dike, unfoliated, fractured

157 int tuff (5a), (Central Showing), recrystallized, sheared, fractured, calcite and albitite veins, foliated

158, 154 albitite dike (23a), (Central Showing), very xenolithic, plag-rich dike, highly sheared, qtz and calcite veins, foliated

159 diorite dike (23b), (Central Showing), fg diorite intrusive containing abundant calcite (30%), sheared, calcite, qtz and albitite veins

160 albitite dike (23a), (Central Showing), plag-rich dike, unfoliated, fractured

E	161	162	163	164	165	166
	48.0	58.7	72.8	53.2	62.6	60.5
	18.9	16.6	12.3	14.1	19.5	15.7
	2.32	1.82	.61	1.67	.78	1.48
	9.7	6.7	1.6	5.6	1.9	6.7
	10.6	5.01	1.40	8.65	1.61	4.76
	4.16	2.36	.40	8.48	.88	1.87
	2.68	3.10	7.09	3.62	9.11	2.40
	.28	1.83	.12	.39	.46	1.92
	1.4	1.2	1.5	1.1	< .1	.5
	< .1	.1	< .1	.1	.1	.2
	.92	.76	.19	.47	.31	.70
	.04	.13	.16	.16	.16	.14
	.21	.14	.06	.16	.06	.14
	.2	.6	1.2	1.0	.6	.7
	.045	.055	1.298	.000	.929	.195
	99.5	99.1	100.8	98.7	99.1	98.0
	92.0	33.0	56.0	5.0	40.0	50.0
	< .5	< .5	20.0	< .5	< .5	< .5
	14.	16.	610.	2.	29.	28.
	14.0	75.0	70.0	18.0	26.0	80.0
	10.	0.	10.	0.	40.	20.
	4.	2.	2.	6.	6.	4.
	20.	70.	270.	50.	460.	80.
	26.	6.	7.	9.	170.	3.
	1.0	.4	2.2	.7	.8	.3
	430.	190.	20.	140.	35.	130.
	24.	34.	62.	346.	55.	51.
	4.0	3.0	8.0	6.0	5.0	4.0
	12.0	14.0	1.0	9.0	1.0	10.0
	2.0	< .5	2.0	47.0	1.0	3.0

asalt check
reywacke (9a), (Central Showing), hornblende and usc-bearing greywacke, sheared, flaser structure, qtz eins, foliated
lbitite dike (23a), (Central Showing), plag-rich dike, nfoliated, fractured
assive andesite (4a), (Cenral Showing), fg recrystal-ized amphibolite, minor shearing, unfoliated
bitite dike (23a), (Central Showing), plag-rich dike, nfoliated, fractured
arnet mica siltstone (9d), (Central Showing), garnet nd musc-bearing siltstone, sheared and fracturing, nor qtz veins, foliated

MPLE	167	168	169	170	171	172
O2	59.6	58.9	58.8	58.1	52.0	54.5
2O3	16.0	16.0	16.3	16.9	14.3	17.3
2O3	1.60	1.66	1.23	1.77	2.82	1.44
O	7.1	7.0	7.0	6.8	10.6	5.4
O	3.96	5.44	4.04	5.06	7.22	5.39
O	2.55	2.45	2.13	2.63	3.83	4.35
2O	3.26	3.25	3.29	3.21	3.55	3.45
O	1.97	1.28	2.15	1.52	.66	2.92
O^+	.5	.1	.6	.3	< .1	1.0
O^-	.1	< .1	< .1	.1	.1	.1
O2	.76	.78	.76	.79	1.48	.77
O5	.13	.13	.14	.14	.34	.24
O	.11	.16	.12	.14	.22	.10
2	.7	.3	.8	.5	1.3	1.9
3	.075	.000	.110	.024	.240	.000
TAL	98.4	97.5	97.5	98.0	98.7	98.9
	48.0	15.0	120.	80.0	75.0	46.0
	< .5	< .5	.5	.5	< .5	.5
	<2.	3.	12.	20.	6.	<2.
	86.0	54.0	74.0	62.0	47.0	64.0
	10.	0.	20.	10.	20.	30.
	<2.	<2.	<2.	2.	6.	8.
	90.	60.	70.	70.	90.	70.
	4.	2.	6.	5.	4.	2.
	.6	.8	.4	.2	.5	.8
	160.	180.	140.	200.	410.	190.
	44.	48.	41.	51.	27.	82.
	4.0	3.0	3.0	4.0	6.0	7.0
	14.0	10.0	14.0	11.0	15.0	21.0
	< .5	1.0	< .5	< .5	5.0	30.0

greywacke (9a), (Central Showing), hornblende and musc-bearing greywacke, sheared, foliated
greywacke (9a), (Central Showing), hornblende and musc-bearing greywacke, sheared, foliated
garnet mica siltstone (9d), (Central Showing), musc, plag, hornblende and garnet-bearing siltstone, sheared, qtz and calcite veins, unfoliated
greywacke (9a), (Central Showing), hornblende and musc-bearing greywacke, sheared, foliated
int tuff (5a), (Central Showing), recrystallized fg groundmass with hornblende porphyroblasts, foliated
siltstone (9b), (Central Showing), musc, calcite and hornblende siltstone, sheared, crenulated, foliated

AMPLE	173	174	175A	175B	176	177
iO2	48.4	48.0	65.8	52.8	53.3	67.3
l2O3	16.1	18.6	16.4	19.3	14.2	16.5
e2O3	1.82	2.43	1.01	1.89	3.18	.50
eO	6.2	5.9	3.7	6.0	11.0	1.9
aO	9.82	8.68	2.27	5.19	6.05	2.19
gO	5.71	3.09	1.17	3.54	4.01	1.03
a2O	3.92	3.86	5.19	4.18	3.44	4.96
2O	1.43	2.48	1.60	2.86	.45	2.42
$2O^+$	.1	.2	< .1	< .1	< .1	< .1
$2O^-$	.2	.1	.1	< .1	.2	.1
iO2	.65	.85	.53	.90	1.32	.42
2O5	.20	.10	.10	.36	.14	.13
nO	.18	.15	.10	.09	.20	.04
O2	3.7	2.8	.3	.9	.2	.9
O3	.000	.300	.000	.165	.070	.005
OTAL	98.4	97.5	98.3	98.3	97.8	98.4
u	1.0	250.	18.0	350.	120.	15.0
g	< .5	1.0	.5	1.0	< .5	< .5
u	9.	16.	30.	23.	9.	2.
n	43.0	58.0	68.0	72.0	28.0	48.0
	0.	20.	20.	40.	30.	0.
	10.	10.	4.	4.	<2.	18.
	50.	70.	170.	90.	60.	120.
	4.	5.	1.	3.	5.	3.
	1.4	1.4	.3	1.0	.6	.2
	210.	180.	20.	130.	430.	44.
	113.	31.	27.	34.	38.	48.
	8.0	6.0	1.0	5.0	3.0	7.0
	17.0	19.0	2.0	20.0	10.0	6.0
	36.0	7.0	< .5	6.0	2.0	8.0

3 siltstone (9b), (Central Showing), hornblende, calcite and musc-bearing siltstone, foliated

4, 175B siltstone (9b), (Cenral Showing), musc and plag-bearing siltstone, foliated

5A siltstone (9b), (Brown Showing), vfg mica, plag and garnet-bearing siltstone, excellent relict bedding, foliated, minor qtz veins

5B siltstone (9b), (Central Showing), musc and plag bearing siltstone, foliated

6 monzodiorite (22b), (Brown Showing), vfg musc, qtz, plag, microcline-bearing xenomorphic dike, foliated and crenulated

7 qtz plag porphyry dike (22a), (Brown Showing), plag and qtz phenocrysts in fg xenomorphic groundmass of plag, mica and qtz

LE	178	179	180	181	182	183
	51.3	57.5	51.1	85.9	60.0	53.7
3	14.9	16.2	13.1	1.5	17.2	13.3
3	1.94	1.40	2.19	.08	1.11	3.46
	10.4	5.8	11.8	.7	4.2	10.2
	7.28	4.34	6.15	.25	4.29	7.60
	5.87	2.87	3.85	.05	2.44	3.74
	2.88	3.35	1.81	.68	3.89	2.58
	.86	3.23	1.85	.23	2.73	.34
	< .1	.2	.1	1.3	.1	.3
	.1	.1	.1	.2	.1	.2
	1.06	.78	1.30	.07	.67	1.24
	.10	.24	.17	.01	.16	.13
	.20	.13	.19	.01	.09	.23
	.6	6.7	2.0	.2	1.2	.5
	.330	.100	.524	2.247	1.174	.120
L	97.9	102.9	96.2	93.5	99.4	97.6
	81.0	110.	160.	190.	110.	88.0
	< .5	1.0	.5	gt10.0	6.0	2.5
	<2.	4.	<2.	7200.	660.	260.
	37.0	120.	97.0	3200.	150.	51.0
	30.	30.	30.	0.	0.	30.
	4.	9.	14.	gt4000.	650.	470.
	50.	90.	60.	20.	110.	70.
	5.	3.	25.	9.	6.	5.
	.6	.9	1.4	16.0	.8	.5
	290.	180.	370.	14.	120.	400.
	44.	44.	31.	116.	65.	48.
	4.	5.	5.	3.	3.	3.
	19.0	17.0	35.0	1.0	20.	11.
	12.0	8.0	< .5	3.0	22.0	3.0

mafic tuff (4f), (Brown Showing), fg poorly bedded, unfoliated, qtz, calcite and chlorite veins

monzodiorite (22b), (Brown Showing), vfg qtz, plag and mica bearing xenomorphic dike, plag veins, sheared, foliated and crenulated

greywacke (9a), (Brown Showing), completely recrystallized penninite and hornblende-bearing greywacke, very sheared, qtz veins, flaser structure, foliated

mineralized qtz vein, (Brown Showing), minor sulfides (5%) with plag (2%) and musc, gold-bearing

monzodiorite (22b), (Brown Showing), vfg qtz, plag, mica bearing xenomorphic dike

greywacke (9a), (Brown Showing), hornblende and chlorite bearing greywacke, fractured, foliated

SAMPLE	184	185	186	187	188	189
SiO2	68.2	53.0	51.4	92.4	52.6	50.5
Al2O3	16.6	13.8	14.2	1.42	14.8	15.5
Fe2O3	.95	3.19	3.89	.50	2.56	3.13
FeO	1.5	10.9	10.9	1.0	11.1	9.6
CaO	2.01	8.19	7.18	.76	6.29	7.35
MgO	1.07	3.96	3.89	.46	4.72	4.33
Na2O	4.76	2.25	2.63	.35	3.19	2.85
K2O	2.41	.69	.99	.24	.64	1.64
$H2O^+$	< .1	2.4	1.3	.3	.8	1.1
$H2O^-$	1.0	.2	.3	.1	.2	.1
TiO2	.42	1.29	1.40	.19	1.38	1.40
P2O5	.13	.15	.16	.02	.14	.17
MnO	.04	.23	.22	.04	.19	.21
CO2	.5	.5	.2	.4	.3	.7
SO3	.000	.255	.135	.300	.779	.000
TOTAL	99.6	101.0	98.8	98.6	99.7	98.6
Cu	6.0	140.	74.0	75.0	150.	130.
Ag	.5	1.0	.5	gt10.0	1.0	.5
Au	43.	51.	35.	gt10000.	22.	81.
Zn	54.0	41.0	47.0	300.	44.0	56.0
Y	10.	10.	30.	0.	30.	30.
Pb	37.	47.	36.	110.	25.	15.
Zr	110.	50.	60.	0.	110.	100.
As	11.	6.	6.	22.	4.	12.
Sb	.2	.8	.9	.5	.8	.8
V	41.	380.	490.	37.	330.	320.
Cr	44.	44.	38.	130.	41.	38.
Mo	3.0	3.0	1.	4.0	1.0	3.0
Co	6.0	14.0	16.0	4.0	22.0	16.0
Ni	6.0	5.0	2.0	5.0	8.0	4.0

184 qtz plag porphyry dike (22a), (Brown Showing), plag and qtz phenocrysts in a fg matrix

185 greywacke (9a), (Brown Showing), completely recrystallized hornblende and musc-bearing greywacke, qtz and calcite veins, no foliation

186 greywacke (9a), (Brown Showing), recrystallized hornblende-bearing greywacke

187 mineralized qtz vein, (Brown Showing), bull qtz vein containing sulfides (2%), musc (2%), minor plag and chlorite

188 greywacke (9a), (Brown Showing), recrystallized hornblende-bearing greywacke, qtz and plag veins, sheared, foliated

189 amygdaloidal basalt (4d), (Brown Showing), recrystallized porphyroblasitc plag (to 2.2mm) in fg matrix, qtz and polymineralic amygdales, sheared, fractured, foliated

SAMPLE	190	191	192	193	194	195
SiO2	53.2	62.7	66.9	67.7	50.4	58.6
Al2O3	13.09	16.6	16.5	16.1	15.1	17.8
Fe2O3	2.54	1.42	1.20	1.10	2.61	1.36
FeO	8.6	4.0	1.7	1.5	10.7	5.3
CaO	8.49	3.30	2.34	1.54	7.42	3.79
MgO	3.93	2.12	1.15	1.05	5.02	2.87
Na2O	3.18	4.95	4.97	5.43	3.07	4.07
K2O	.54	1.49	2.28	1.99	.55	2.63
H_2O^+	.6	.8	.3	.6	1.4	.8
H_2O^-	< .1	.2	< .1	< .1	< .1	.1
TiO2	1.44	.60	.44	.46	1.13	.82
P2O5	.22	.13	.13	.13	.10	.19
MnO	.20	.12	.04	.04	.24	.10
CO2	1.1	.1	.8	.3	.8	.5
SO3	.135	.000	.000	.000	.000	.015
TOTAL	98.1	98.5	98.8	97.9	98.6	98.6
Cu	45.0	4.0	11.0	3.0	< .5	37.0
Ag	< .5	.5	< .5	< .5	< .5	1.0
Au	12.	6.	71.	<2.	29.	4.
Zn	25.0	120.	62.0	53.0	40.0	110.
W	40.	30.	0.	10.	40.	10.
Pb	23.	6.	31.	42.	6.	18.
Zr	130.	160.	110.	120.	90.	100.
As	6.	3.	7.	5.	7.	5.
Sb	.5	< .2	.3	< .2	.8	1.1
V	280.	65.	49.	47.	350.	180.
Cr	38.	51.	44.	55.	27.	68.
Mo	5.0	1.0	4.0	1.0	2.0	1.0
Co	10.0	5.0	7.0	5.0	14.0	19.0
Ni	4.0	3.0	8.0	6.0	2.0	6.0

190 greywacke (9a), (Brown Showing), plag-rich hornblende bearing greywacke, minor shearing, calcite veins, foliated

191 siltstone (9b), (Brown Showing), vfg well bedded musc bearing siltstone

192 qtz plag porphyry dike (22a), (Brown Showing), cg, anhedral plag and qtz phenocrysts (to 2.3mm) in fg xenomorphic groundmass of plag, musc and qtz, foliated

193 qtz plag porphyry dike (22a), (Brown Showing), cg anhedral plag and qtz phenocrysts in a fg xenomorphic matrix of plag, qtz and mica, qtz veins, foliated

194 greywacke (9a), (Brown Showing), completely recrystallized hornblende, penninite and calcite-bearing meta greywacke, sheared, qtz veins

195 monzodiorite (22b), (Brown Showing), vfg qtz, mica, and plag bearing xenomorphic dike, foliated, crenulated, sheared, opaque filled fractures

LE	196	197	198	199	200	201
	67.2	51.1	59.7	67.4	70.0	58.1
3	16.5	14.2	17.6	16.7	15.3	15.7
3	.77	3.12	1.36	1.05	.92	1.36
	1.7	11.5	4.4	1.8	1.7	7.0
	2.13	6.08	4.02	2.10	2.46	4.94
	1.01	3.89	2.61	1.25	1.08	2.41
	4.98	2.22	4.13	4.08	3.80	3.21
	2.38	2.07	2.31	2.92	2.32	2.04
	.4	1.1	.5	.4	.3	1.2
	< .1	.1	.1	.1	< .1	< .1
	.41	1.39	.72	.47	.42	.77
	.13	.16	.17	.14	.12	.12
	.04	.20	.10	.04	.04	.12
	.9	.3	.7	.1	.1	1.0
	.005	.804	.684	.015	.170	.000
L	98.6	98.2	99.1	98.2	98.8	98.0
	16.0	190.	62.0	15.0	16.0	30.0
	.5	1.0	1.0	1.0	< .5	< .5
	<2.	4.	7.	32.	5.	21.
	51.0	56.0	76.0	57.0	56.0	78.0
	0.	30.	10.	10.	0.	20.
	21.	<2.	14.	12.	64.	4.
	120.	60.	120.	120.	100.	70.
	6.	6.	2.	7.	5.	2.
	.5	.7	.2	.3	.3	.2
	45.	460.	130.	60.	44.	180.
	44.	34.	62.	48.	55.	44.
	4.0	1.0	2.0	1.0	< .5	1.0
	7.0	31.0	20.0	7.0	5.0	15.0
	8.0	2.0	21.0	5.0	4.0	< .5

qtz plag porphyry dike (22a), (Brown Showing), anhedral cg plag and qtz phenocrysts in a xenomorphic matrix of plag, qtz and mica, foliated, xenoliths

greywacke (9a), (Brown Showing), recrystallized hornblende and musc-bearing greywacke, qtz, calcite and chlorite veins, foliated

nonzodiorite (22b), (Brown Showing), vfg qtz, plag, nica bearing xenomorphic dike

qtz plag porphyry dike (22a), (Brown Showing), cg plag and qtz phenocrysts in fg matrix

qtz plag porphyry dike (22a), (Brown Showing), porphyritic, cg plag and qtz in fg matrix of plag, qtz and nusc, fractured, xenoliths, qtz veins, foliated

jreywacke (9a), (Central Showing), penninite and hornblende-bearing greywacke, sheared, qtz and calcite veins, foliated

PLE	202	203	204	205	206	207
2	63.1	62.1	63.5	50.9	59.5	49.5
O3	15.1	15.7	15.5	14.4	15.9	15.2
O3	3.70	1.42	1.28	2.50	1.99	2.84
	3.5	7.1	5.6	9.9	6.2	9.5
	5.14	3.55	3.00	8.19	5.80	8.24
	2.01	1.64	1.66	4.95	2.41	4.76
O	3.01	2.71	3.58	3.03	3.01	3.24
	1.35	2.37	2.03	.52	1.42	.47
-	.6	.9	.9	.7	.7	1.6
-	.1	.1	.1	.1	< .1	< .1
2	.71	.68	.68	1.28	.74	1.27
5	.12	.13	.13	.25	.15	.15
	.14	.11	.08	.21	.14	.24
	.9	.1	.5	.8	.9	1.6
	.000	.090	.534	.440	.000	.060
AL	99.5	98.7	99.1	98.2	98.9	98.7
	140.	50.0	32.0	190.	56.0	51.0
	< .5	< .5	.5	.5	.5	.5
	41.	13.	47.	13.	68.	8.
	59.0	85.0	96.0	36.0	52.0	50.0
	0.	10.	30.	10.	20.	10.
	6.	°2.	6.	4.	6.	8.
	60.	80.	80.	60.	80.	100.
	2.	3.	2.	7.	3.	6.
	.3	.2	.4	.5	.6	.5
	150.	100.	80.	370.	170.	300.
	44.	41.	38.	34.	41.	41.
	3.0	< .5	< .5	3.0	3.0	4.0
	10.0	10.0	14.0	17.0	12.0	18.0
	< .5	< .5	< .5	11.0	2.0	7.0

greywacke (9a), (Central Showing), musc and hornblende bearing greywacke, foliated

garnet mica siltstone (9d), (Central Showing), garnet and musc siltstone, foliated

siltstone (9b), (Central Showing), musc-bearing siltstone, sheared, crenulated, foliated

greywacke (9a), (Central Showing), hornblende-bearing greywacke, minor shearing, unfoliated

greywacke (9a), (Central Showing), hornblende, musc and calcite-bearing greywacke, sheared, calcite veins, foliated

greywacke (9a), (Central Showing), hornblende bearing greywacke, foliated

PLE	208	209
2	69.8	67.9
D3	16.9	14.2
D3	1.39	2.18
	.4	3.7
	1.40	3.55
	.68	.80
D	3.76	3.16
	2.77	1.57
+	.9	.5
-	.1	< .1
2	.21	.45
5	.05	.09
	.04	.09
	2.0	.9
	1.249	.005
AL	101.6	99.1
	1.0	43.0
	< .5	< .5
	6.	<2.
	17.0	39.0
	0.	-.-
	2.	-.-
	80.	2.
	3.	-.-
	.6	-.-
	22.	3.
	44.	0.
	3.	37.
	2.0	-.-
	2.0	-.-

granodiorite dike (17), (Tornado), cataclastic, mg plag qtz, and k-spar crystoblasts in fg matrix of plag, qtz, k-spar and mica, sheared

dacitic tuff (6a), (Mirage), completely recrystallized, folded and sheared

Appendix B

NORMATIVE CALCULATIONS DERIVED FROM CHEMICAL DATA

The following appendix is the normative calculations rived from the geochemical data (appendix A). The data is ranged serially according to geochemical sample numbers. ese data represent volatile-free and FeO corrected norms. e geochemical number, rock type and subunit designation is ven below each normative calculation.

Abbreviations used in this appendix are:

--------normative albite
--------normative anorthite
--------normative anorthite plagioclase content
yg------amygdaloidal
--------normative apatite
--------normative color index
--------normative corundum
--------normative diopside
--------normative hematite
--------normative hypersthene
--------normative ilmenite
--------intermediate
--------normative magnetite
--------normative nepheline
--------normative olivine
--------normative orthoclase
g------plagioclase
ph----porphyry
-------quartz
-------normative quartz

LE 001	002	003	004	005	006	007	008
8.50	14.70	10.41	17.45	29.47	31.08	17.04	10.9
-.-	1.22	0.32	-.-	0.22	5.69	4.16	-.-
22.13	17.03	3.21	11.05	7.88	16.97	14.04	17.41
17.56	18.66	23.26	24.70	28.46	41.71	22.67	20.03
29.83	25.61	35.78	27.09	19.31	1.33	21.28	24.11
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
0.92	-.-	-.-	5.45	-.-	-.-	-.-	9.24
15.78	17.62	21.20	10.05	10.36	1.03	15.62	13.31
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
3.41	3.43	3.72	2.96	2.99	1.28	3.40	3.25
-.-	-.-	-.-	-.-	-.-	0.28	-.-	-.-
1.60	1.39	1.84	1.07	1.08	0.49	1.47	1.32
0.28	0.34	0.25	0.18	0.23	0.15	0.32	0.44
100.01	100.01	100.01	100.00	100.00	100.00	100.01	100.01
62.95	57.85	60.60	52.31	40.43	3.10	48.42	54.62
21.72	22.44	26.77	19.54	14.47	3.07	20.49	27.12

LE 009	010	011	012	013	014	015	016
5.65	9.67	3.98	3.06	-.-	1.35	-.-	3.06
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.37	20.98	4.16	-.-	4.62	2.08	1.71	3.18
21.90	16.65	29.67	15.00	16.41	25.36	22.71	25.92
30.38	28.81	24.84	16.53	30.53	26.96	38.08	25.04
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
11.76	3.88	20.00	31.24	20.83	21.14	13.68	14.79
23.10	14.61	12.10	20.57	19.56	17.27	14.48	21.36
-.-	-.-	-.-	5.82	2.66	-.-	3.76	-.-
3.74	3.56	3.35	4.00	3.46	3.64	3.64	4.04
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.76	1.59	1.74	2.38	1.56	1.83	1.82	2.34
0.37	0.25	0.16	1.42	0.37	0.39	0.12	0.29
100.01	100.01	100.00	100.03	100.01	100.01	100.00	100.01
58.10	63.37	45.57	52.43	65.03	51.53	62.64	49.14
40.35	23.64	37.19	64.01	48.08	43.88	37.39	42.52

ltered mafic tuff (4fa)
ltered mafic tuff (4fa)
ltered mafic tuff (4fa)
acitic tuff (5b)
acitic tuff (5b)
z vein
acitic tuff (5b)
.tered mafic tuff (4fa)

009 altered mafic tuff (4fa)
010 altered mafic tuff (4fa)
011 int. tuff (5a)
012 porphyritic gabbro (13)
013 altered mafic tuff (4fa)
014 massive basaslt (4b)
015 basalt check
016 amyg basalt (4d)

017	018	019	020	021	022	023	024
4.75	23.39	26.65	8.42	26.00	16.32	5.97	22.00
-.-	-.-	-.-	-.-	1.84	-.-	-.-	1.17
3.73	10.77	6.61	3.34	19.45	5.22	2.88	16.77
).78	42.17	41.95	30.80	23.19	28.55	25.73	37.31
7.66	15.10	10.13	21.05	17.42	25.27	29.65	14.63
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
.69	0.09	7.18	25.99	-.-	5.09	12.00	-.-
7.58	5.22	3.63	5.96	9.20	15.44	18.93	5.57
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
2.77	2.63	2.16	2.77	2.15	2.71	3.25	5.57
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
).84	0.46	1.24	1.52	0.58	1.14	1.30	0.62
).20	0.17	0.45	0.16	0.18	0.25	0.29	0.32
).00	100.00	100.01	100.00	100.00	100.00	100.01	100.00
5.47	26.37	19.46	40.60	42.89	46.95	53.54	28.17
2.89	8.40	14.21	36.23	11.93	24.38	35.48	7.82

025	026	027	028	029	030	031	032
.46	21.63	22.21	-.-	27.63	26.78	15.84	16.47
.04	1.04	2.09	-.-	3.43	2.60	0.38	1.19
.37	19.68	20.29	6.67	11.87	20.61	3.56	3.67
.69	38.55	40.07	27.68	12.32	23.10	28.24	27.82
.19	15.49	8.77	25.33	18.76	15.62	26.87	25.02
.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
.-	-.-	-.-	17.57	-.-	-.-	-.-	-.-
.51	15.49	5.35	15.40	22.98	8.52	19.83	20.54
.-	-.-	-.-	15.40	-.-	-.-	-.-	-.-
.75	-.-	0.43	3.71	1.01	1.98	3.29	3.24
.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
.61	0.18	0.53	1.89	1.66	0.62	1.66	1.70
.40	0.35	0.27	0.22	0.34	0.17	0.33	0.35
.01	100.00	100.00	100.01	100.01	100.00	100.01	100.01
.22	28.66	17.96	47.78	60.36	40.33	48.76	47.35
.86	3.00	6.30	40.01	25.65	11.12	24.79	25.83

uff (5a)
diorite dike (17)
ic tuff (5b)
uff (5a)
ic tuff (5b)
uff (5a)
acke (9a)
diorite (16a)

025 int tuff (5a)
026 granodiorite (16a)
027 granodiorite (16a)
028 greywacke (9a)
029 laminated siltstone (9b)
030 dacitic tuff (5b)
031 int lapilli tuff (5a)
032 int lapilli tuff (5a)

LE 033	034	035	036	037	038	039	040A
23.41	4.36	3.80	22.69	-.-	3.58	-.-	-.-
1.52	-.-	-.-	2.00	-.-	-.-	-.-	-.-
17.97	8.98	6.95	19.03	3.61	2.35	3.12	1.77
38.80	28.85	43.32	39.68	28.79	26.97	25.25	22.82
11.25	29.83	22.50	9.17	34.56	23.14	34.52	38.61
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
-.-	4.26	8.19	-.-	11.33	11.88	14.27	12.51
3.36	18.87	9.76	4.21	9.79	23.94	16.18	17.11
-.-	-.-	-.-	-.-	6.31	-.-	1.19	1.77
2.72	2.32	3.39	2.24	3.60	4.55	3.56	3.49
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
0.64	1.77	1.45	0.65	1.77	2.97	1.71	1.81
0.34	0.78	0.65	0.34	0.24	0.65	0.20	0.10
100.00	100.02	100.01	100.00	100.01	100.02	100.00	100.00
22.48	50.83	34.18	18.77	54.56	46.18	57.75	62.85
6.72	27.22	22.80	7.09	32.80	43.33	36.91	36.70

LE 040B	041	042	043	044	045	046	047
-.-	-.-	14.54	21.89	3.13	8.37	21.26	29.05
-.-	-.-	1.48	-.-	0.02	-.-	-.-	4.26
1.71	3.24	12.53	5.87	5.73	2.31	3.72	14.29
23.22	27.67	30.89	27.99	26.78	24.46	36.97	46.14
37.49	36.23	19.22	24.61	38.10	22.92	19.41	2.51
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
14.21	9.40	-.-	0.94	-.-	11.21	2.52	-.-
13.84	8.14	16.79	14.08	20.58	22.33	10.89	1.18
3.91	9.66	-.-	-.-	-.-	-.-	-.-	-.-
3.66	3.63	2.79	3.22	3.50	4.35	3.43	1.32
-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.57
1.86	1.81	1.45	1.20	1.90	3.28	1.51	0.53
0.10	0.22	0.31	0.20	0.28	0.78	0.30	0.15
100.00	100.01	100.01	100.00	100.01	100.02	100.00	100.00
61.76	56.69	38.35	46.78	58.73	48.38	34.43	5.15
37.49	32.64	21.04	19.44	25.97	41.18	18.36	3.60

ranodiorite (16a)
abbro (13)
reywacke (9a)
ranodiorite (16a)
myg basalt (2d)
assive andesite (2a)
myg basalt (2d)
basalt check

040B basalt check
041 amyg basalt (2d)
042 greywacke (9a)
043 dacitic tuff (5b)
044 altered mafic tuff (4fa)
045 amyg andesite (2a)
046 int tuff (5a)
047 qtz vein

AMPLE	048	049	050	051	052	053	054	055
QZ	12.31	7.71	-.-	25.73	26.11	16.23	10.77	17.21
CO	-.-	-.-	-.-	0.61	1.26	-.-	-.-	0.89
OR	6.48	10.72	4.33	16.17	16.02	11.01	2.62	9.31
AB	32.54	18.62	24.36	42.04	44.64	26.83	31.69	23.16
AN	22.66	26.35	28.62	11.45	8.91	20.15	20.44	21.60
NE	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
DI	5.56	7.63	16.56	-.-	-.-	7.58	6.66	-.-
HY	15.39	22.85	16.35	2.02	0.93	12.82	19.89	21.40
OL	-.-	-.-	3.88	-.-	-.-	-.-	-.-	-.-
MT	3.30	3.03	3.61	1.40	0.17	3.48	4.38	3.79
HM	-.-	-.-	-.-	-.-	1.48	-.-	-.-	-.-
IL	1.37	2.59	1.75	0.45	0.39	1.62	2.80	1.95
AP	0.39	0.51	0.55	0.12	0.10	0.29	0.76	0.73
SUM	100.01	100.01	100.01	100.00	100.00	100.00	100.02	100.02
An	41.05	58.60	54.02	21.41	16.65	42.89	39.22	48.25
CI	25.62	36.11	42.16	3.87	2.97	25.50	33.74	27.13

AMPLE	056	057	058	059	060	061	062	063
QZ	1.29	1.47	-.-	-.-	1.43	16.84	5.04	7.10
CO	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
OR	4.03	2.28	1.78	1.71	2.42	8.38	2.37	1.77
AB	26.00	27.03	31.34	22.74	20.91	31.77	26.31	26.02
AN	25.11	26.11	37.68	37.85	23.79	22.94	23.22	30.80
NE	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
DI	17.32	17.28	8.52	13.58	23.76	5.58	15.63	8.22
HY	19.78	19.51	8.88	16.97	22.86	9.93	20.16	21.05
OL	-.-	-.-	7.35	1.59	-.-	-.-	-.-	-.-
MT	3.88	3.80	3.11	3.64	3.23	3.11	4.23	3.36
HM	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
IL	2.09	2.00	1.12	1.83	1.30	1.16	2.61	1.46
AP	0.52	0.52	0.22	0.10	0.32	0.29	0.44	0.22
SUM	100.01	100.01	100.00	100.00	100.01	100.00	100.01	100.00
An	49.13	49.13	54.60	62.47	53.22	41.93	46.88	54.20
CI	43.07	42.60	28.99	37.60	51.14	19.78	42.64	34.09

18 greywacke (9a)
19 greywacke (9a)
50 greywacke (9a)
51 granodiorite dike (17)
52 granodiorite dike (17)
53 dacitic lapilli tuff (5b)
54 massive andesite (4a)
55 dacitic tuff (5b)

056 massive andesite (4a)
057 greywacke (9a)
058 mafic tuff (4f)
059 basalt check
060 porphyritic basalt (3b)
061 laminated siltstone (9b)
062 massive andesite (2a)
063 mafic tuff (4f)

PLE 064	065	066	067	069	070	071	072
Z 1.70	9.64	0.42	7.03	-.-	6.27	-.-	-.-
D -.-	-.-	-.-	0.07	-.-	-.-	-.-	-.-
R 1.90	2.13	3.43	8.22	10.91	1.40	10.65	1.64
B 20.78	30.69	39.02	27.48	26.97	28.10	24.22	23.15
N 25.63	21.73	16.89	31.53	32.58	23.23	27.91	37.41
E -.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
I 21.54	6.64	12.70	-.-	2.24	12.19	10.82	14.16
Y 23.41	21.03	19.04	20.27	15.16	21.19	12.31	15.69
L -.-	-.-	-.-	-.-	3.45	-.-	8.21	2.45
T 3.32	4.48	4.70	3.51	3.45	4.25	3.55	3.61
H -.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
L 1.40	2.94	3.21	1.64	1.59	2.90	1.72	1.80
P 0.32	0.73	0.61	0.27	0.29	0.49	0.61	0.10
I 100.01	100.02	100.01	100.01	100.01	100.01	100.01	100.00
a 55.23	41.46	30.21	53.43	54.72	45.25	53.53	61.78
I 49.67	35.09	39.65	25.41	29.25	40.53	36.62	37.70

PLE 073	074	075	076	077	078	079	080
15.02	0.59	3.48	12.53	4.21	6.02	-.-	-.-
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
8.40	7.04	3.11	5.46	4.37	0.98	14.66	2.38
34.06	32.74	25.71	34.38	16.50	32.05	20.38	23.93
22.40	27.01	24.40	19.43	34.99	20.81	28.59	25.26
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
7.08	13.43	19.96	21.79	19.49	9.99	7.99	19.64
8.48	13.68	15.15	0.32	14.94	21.37	11.50	17.20
-.-	-.-	-.-	-.-	-.-	-.-	11.87	3.87
3.12	3.39	4.60	3.55	3.45	4.86	3.28	4.35
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.15	1.52	3.22	1.97	1.60	3.47	1.34	2.96
0.29	0.61	0.37	0.57	0.46	0.46	0.39	0.42
100.00	100.01	100.01	100.01	100.01	100.01	100.01	100.01
39.67	45.20	48.69	36.10	67.96	39.37	58.39	51.35
19.84	32.03	42.93	27.63	39.49	39.69	35.98	48.03

orphryitic basalt (3b)
nt tuff (5a)
assive andesite (2a)
assive siltstone (9b)
afic tuff (4f)
assive andesite (2a)
reywacke (9a)
asalt check

073 laminated siltstone (9b)
074 greywacke (9a)
075 int tuff (4g)
076 porphyritic andesite (3c)
077 greywacke (9a)
078 int tuff (4g)
079 greywacke (9a)
080 massive basalt (2b)

LE 081	082	083	084	085	086	087	088
-.-	6.64	24.34	9.95	6.18	27.44	-.-	24.88
-.-	-.-	-.-	-.-	-.-	0.34	-.-	1.48
1.72	1.61	0.91	2.57	1.67	12.40	12.05	13.20
23.77	23.74	34.07	22.04	24.73	44.17	36.79	13.20
37.17	25.16	20.15	22.56	24.21	11.75	23.85	14.95
-.-	-.-	-.-	3.38	-.-	-.-	-.-	-.-
14.31	22.37	3.17	32.86	19.06	-.-	11.91	-.-
13.34	12.67	12.32	-.-	16.02	1.36	8.36	4.37
4.33	-.-	-.-	-.-	-.-	-.-	1.34	-.-
3.47	4.43	3.17	4.09	4.63	1.05	3.53	1.97
-.-	-.-	-.-	-.-	-.-	0.85	3.53	1.97
1.79	2.82	1.46	2.27	3.09	0.49	0.52	0.62
0.10	0.57	0.41	0.28	0.42	0.15	0.52	0.19
100.00	100.01	100.01	100.01	100.01	100.00	100.01	100.00
60.99	51.46	37.16	50.58	49.47	21.01	39.33	28.07
37.25	42.29	20.12	39.22	42.81	3.75	26.80	6.96

LE 089	090	091	092	093	094	095	096
-.-	2.32	-.-	-.-	25.78	-.-	3.37	-.-
-.-	-.-	-.-	-.-	0.38	-.-	-.-	-.-
3.45	2.13	0.85	1.82	16.23	4.98	16.70	6.69
16.92	26.02	40.04	11.64	41.24	16.72	20.33	33.73
36.19	26.24	19.77	21.74	12.47	20.70	28.69	27.44
-.-	-.-	-.-	2.21	-.-	-.-	-.-	-.-
13.67	16.84	9.20	38.77	-.-	23.50	5.26	12.02
15.01	20.74	21.02	-.-	1.72	20.09	20.08	6.19
12.02	-.-	1.53	18.85	-.-	8.85	-.-	8.17
2.46	3.59	4.16	3.29	1.17	2.76	3.41	3.49
-.-	-.-	-.-	-.-	0.49	-.-	-.-	-.-
0.26	1.76	2.96	1.29	0.41	1.88	1.53	1.67
.02	0.37	0.47	0.40	0.12	0.54	0.66	0.63
100.00	100.01	100.01	100.01	100.00	100.01	100.01	100.01
68.14	50.21	33.06	58.66	23.21	55.33	58.54	44.86
43.42	42.93	38.87	62.20	3.78	57.08	30.27	31.53

)asalt check
)orphyritic basalt (4e)
)reywacke (9a)
)orphyritic basalt (4e)
ıassive andesite (2a)
)ranodiorite dike (17)
)reywacke (9a)
)ranodiorite (16a)

089 subvolcanic intrusive (1)
090 massive basalt (4b)
091 int tuff (4g)
092 porphyritic basalt (3b)
093 granodiorite (17)
094 porphyritic basalt (3b)
095 massive siltstone (9b)
096 greywacke (9a)

PLE 097	098	099	100	101	102	103	104
-.-	5.47	-.-	21.22	25.90	6.08	-.-	22.51
-.-	-.-	-.-	2.07	0.39	-.-	-.-	-.-
12.44	2.53	3.56	13.08	18.88	8.85	1.42	9.67
20.18	10.23	8.62	33.74	35.93	22.74	22.26	32.45
28.27	36.83	15.11	15.54	14.88	28.02	32.78	21.48
-.-	-.-	7.47	-.-	-.-	-.-	-.-	-.-
-.-	-.-	1.78	-.-	-.-	-.-	-.-	-.-
11.20	24.40	59.76	-.-	-.-	9.10	22.82	0.10
17.27	15.57	-.-	10.05	1.72	19.85	10.50	9.37
5.70	-.-	-.-	-.-	-.-	-.-	-.-	3.21
3.26	3.31	2.86	2.17	1.08	3.41	3.21	3.07
-.-	-.-	-.-	-.-	0.61	-.-	-.-	-.-
1.31	1.37	0.62	1.45	0.47	1.54	2.64	1.11
0.39	0.30	0.23	0.68	0.15	0.41	0.25	0.24
100.01	100.01	100.01	100.01	100.00	100.01	100.01	100.00
58.34	78.26	41.78	31.53	29.29	55.20	59.55	39.83
38.73	44.65	63.24	13.68	3.87	33.90	43.29	13.65

LE 105	106	107	108	109	110	111A	111B
-.-	6.79	-.-	0.35	29.47	-.-	15.80	18.15
-.-	-.-	-.-	-.-	2.37	-.-	0.89	2.01
13.52	5.22	5.21	1.89	15.26	2.00	8.68	9.48
39.93	23.99	35.79	23.02	41.16	7.41	20.79	19.81
22.89	26.89	23.67	37.36	8.13	24.72	29.22	25.04
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
9.58	15.98	15.22	13.16	-.-	20.39	-.-	-.-
7.79	15.90	13.59	18.65	1.38	29.86	19.78	20.62
0.91	-.-	0.69	-.-	-.-	11.08	-.-	-.-
3.39	3.37	3.56	3.64	0.35	2.86	3.33	3.33
1.49	1.46	1.77	1.83	0.47	1.24	1.38	1.36
0.51	0.39	0.52	0.10	0.12	0.45	0.18	0.20
100.01	100.01	100.01	100.00	100.00	100.01	100.00	100.00
36.44	52.85	39.81	61.88	16.50	76.94	58.43	55.82
23.17	36.72	34.83	37.28	3.48	65.44	24.44	25.31

reywacke (9a)
reywacke (9a)
orphyritic basalt (3b)
acitic lapilli tuff (4i)
ranodiorite dike (17)
reywacke (9a)
orphyritic basalt (4e)
aminated siltstone (9b)

105 greywacke (9a)
106 greywacke (9a)
107 porphyritic breccia (3c)
108 basalt check
109 granodiorite dike (17)
110 subvolcanic intrusive (1)
111A dacitic tuff (5b)
111B dacitic tuff (5b)

E 112	113	114	115	116	117	118	119
19.20	18.72	5.33	7.22	-.-	6.38	5.40	8.03
-.-	4.26	-.-	-.-	-.-	-.-	-.-	-.-
9.89	2.04	9.08	1.42	1.26	5.84	5.88	2.19
27.52	33.56	26.10	16.64	25.58	28.51	25.09	32.27
24.41	17.12	26.09	30.71	31.12	24.24	32.12	26.78
-.-	-.-	-.-	-.-	0.59	-.-	-.-	-.-
0.44	-.-	14.07	12.83	27.56	15.28	8.47	3.99
14.09	18.35	14.25	25.80	-.-	14.57	17.01	21.39
-.-	-.-	-.-	-.-	7.91	-.-	-.-	-.-
2.62	3.72	3.32	3.32	3.38	3.36	3.71	3.39
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.44	1.90	1.41	1.87	2.41	1.44	1.91	1.51
0.39	0.35	0.37	0.20	0.20	0.37	0.42	0.46
100.01	100.01	100.01	100.00	100.00	100.01	100.01	100.01
47.01	33.78	49.99	64.85	53.96	45.95	56.15	45.36
18.59	23.97	33.04	43.82	41.26	34.66	31.10	30.28

E 120	121	122	123	124	125	126	127
-.-	9.31	20.36	8.55	0.13	30.61	11.72	11.05
-.-	-.-	-.-	-.-	-.-	2.19	4.08	0.30
1.16	1.58	10.02	14.89	1.64	14.54	28.70	3.09
27.08	22.56	37.16	22.39	22.25	40.26	13.55	29.71
27.46	27.26	14.46	25.92	37.83	8.77	22.01	32.25
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
11.35	12.12	12.17	2.43	13.75	-.-	-.-	-.-
17.01	19.28	2.23	20.06	18.81	1.33	15.26	17.22
8.31	-.-	-.-	-.-	-.-	-.-	-.-	-.-
3.85	4.42	2.78	3.04	3.65	1.50	3.24	3.98
-.-	-.-	-.-	-.-	-.-	0.26	-.-	-.-
3.46	2.86	0.67	2.20	1.85	0.43	1.23	2.17
0.34	0.63	0.15	0.53	0.10	0.12	0.20	0.23
00.01	100.01	100.00	100.01	100.00	100.00	100.00	100.00
50.34	54.71	28.02	53.65	62.96	17.89	61.90	52.05
42.97	38.68	17.85	27.73	38.06	3.51	19.74	23.37

ltstone (9b) 120 massive basalt (4b)
/g andesite (4c) 121 massive basalt (2b)
:phyritic andesite (3a) 122 siltstone (9b)
eywacke (9a) 123 greywacke (9a)
ssive basalt (4b) 124 basalt check
:phyritic andesite (3a) 125 granodiorite dike (17)
eywacke (9a) 126 int tuff (5a)
eywacke (9a) 127 altered mafic tuff (4fa)

LE 128	129	130	131	132	133	134	135
16.92	2.03	9.32	11.96	8.87	6.23	17.67	15.54
-.-	-.-	-.-	4.37	-.-	-.-	-.-	1.12
9.55	5.14	4.25	29.65	2.33	2.23	3.64	2.08
28.73	23.69	23.71	15.06	21.47	31.85	37.04	28.34
20.41	28.85	25.38	15.06	28.98	26.33	20.59	28.40
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
8.96	6.96	14.90	-.-	10.91	5.73	6.01	-.-
10.26	27.37	17.33	19.02	19.70	22.23	11.10	19.96
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
3.39	3.66	3.35	3.36	4.08	3.45	2.37	3.19
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.50	1.77	1.42	1.41	2.89	1.53	1.25	1.22
0.29	0.53	0.35	0.47	0.78	0.42	0.34	0.15
100.00	100.01	100.01	100.01	100.02	100.01	100.01	100.00
41.54	54.91	51.70	49.39	57.45	45.26	35.72	50.05
24.10	39.77	37.00	23.79	37.58	32.94	20.72	24.37

LE 136	137	138	139	140	141	142	143
2.93	-.-	11.37	24.31	-.-	3.29	-.-	-.-
-.-	-.-	-.-	2.11	-.-	-.-	-.-	-.-
2.02	1.72	13.86	12.60	6.43	2.13	1.96	15.59
20.98	23.17	31.76	51.67	24.48	20.47	25.92	12.61
26.36	37.23	20.56	6.05	21.54	25.43	26.35	32.40
-.-	-.-	-.-	-.-	-.-	-.-	-.-	8.01
15.04	13.40	7.52	-.-	11.70	21.58	19.35	13.18
25.52	18.87	9.43	1.26	11.70	20.03	18.96	-.-
-.-	0.06	-.-	-.-	5.64	-.-	1.83	12.70
3.76	3.64	3.38	-.-	3.57	3.62	3.52	3.67
-.-	-.-	-.-	1.49	-.-	-.-	-.-	-.-
3.09	1.81	1.50	0.28	2.65	3.12	1.66	1.70
-.-	-.-	-.-	0.10	-.-	-.-	-.-	-.-
0.29	0.10	0.63	0.12	0.23	0.33	0.47	0.15
100.01	100.00	100.01	100.00	100.01	100.01	100.01	100.00
55.68	61.64	39.30	10.48	46.81	55.40	50.41	55.52
47.41	37.78	21.84	3.03	47.33	48.36	46.31	31.25

acitic lapilli tuff (5b)
reywacke (9a)
reywacke (9a)
assive siltstone (9b)
reywacke (9a)
reywacke (9a)
aminated siltstone (9b)
aminated siltstone (9b)

136 greywacke (9a)
137 basalt check
138 massive siltstone (9b)
139 granodiorite dike (17)
140 greywacke (9a)
141 greywacke (9a)
142 greywacke (9a)
143 laminated siltstone (9b)

LE	144	145A	145B	146	147	148	149	150
	8.39	10.21	-.-	-.-	-.-	10.13	0.94	3.99
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	3.13	2.81	1.91	3.70	1.88	1.93	1.20	6.34
	22.14	30.64	24.02	20.76	28.86	32.99	30.56	28.82
	25.50	20.45	31.42	29.45	27.07	22.20	38.46	20.27
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	8.80	10.00	13.98	25.04	17.75	10.89	4.20	13.24
	24.66	17.66	14.27	6.83	10.54	13.62	18.87	19.91
	-.-	-.-	9.31	9.29	8.71	-.-	-.-	-.-
	4.25	4.52	3.39	3.36	3.42	4.53	3.78	3.67
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	2.60	2.97	1.48	1.37	1.56	3.02	1.89	2.96
	0.54	0.76	0.22	0.20	0.22	0.70	0.10	0.82
	100.01	100.02	100.01	100.01	100.01	100.02	100.00	100.02
	53.53	40.03	56.67	58.65	48.40	40.22	55.72	41.29
	40.31	35.14	42.44	45.89	41.97	32.07	28.74	39.78

LE	151	152	153	154	155	156	157	158
	12.76	2.64	15.39	-.-	-.-	15.09	-.-	-.-
	1.86	-.-	4.18	-.-	-.-	1.77	-.-	-.-
	7.98	7.54	10.65	13.50	4.59	5.95	12.92	12.78
	64.25	29.66	61.36	18.76	39.54	69.48	20.88	21.64
	6.63	21.04	3.25	8.10	14.51	2.66	8.17	7.17
	-.-	-.-	-.-	12.09	2.33	-.-	10.56	10.78
	-.-	9.78	-.-	30.91	19.43	-.-	11.67	31.44
	3.65	21.43	1.68	-.-	-.-	1.53	-.-	-.-
	-.-	-.-	-.-	10.54	12.38	-.-	11.67	9.10
	1.88	4.08	1.99	2.40	4.29	2.61	2.81	3.43
	-.-	-.-	0.49	-.-	-.-	0.02	-.-	-.-
	0.59	3.00	0.62	2.42	2.54	0.53	2.44	2.41
	0.41	0.84	0.39	1.33	0.38	0.36	1.43	1.27
	100.01	100.02	100.00	100.03	100.01	100.00	100.03	100.03
	9.35	41.50	5.30	17.23	25.04	3.69	17.51	15.33
	6.12	38.29	4.79	46.26	38.65	4.69	46.08	46.39

amyg basalt (2d)
massive andesite (4a)
porphyritic gabbro (13)
porphyritic gabbro (13)
massive andesite (2a)
massive andesite (2a)
greywacke (9a)
greywacke (9a)

151 albitite dike (23a)
152 greywacke (9a)
153 albitite dike (23a)
154 albitite dike (23a)
155 int tuff (5a)
156 albitite dike (23a)
157 int tuff (5a)
158 albitite dike (23a)

PLE	159	160	161	162	163	164	165	166
	0.25	-.-	-.-	15.76	28.85	0.60	2.49	22.80
	-.-	-.-	-.-	0.74	-.-	-.-	1.51	1.41
	0.97	1.06	1.69	11.13	0.73	2.39	2.79	11.78
	40.65	19.63	23.18	27.00	62.02	31.74	79.16	21.09
	5.35	7.39	39.58	24.71	1.43	21.84	7.13	23.57
	-.-	17.26	-.-	-.-	-.-	-.-	-.-	-.-
	43.04	45.60	11.65	-.-	3.97	17.34	-.-	-.-
	4.09	-.-	14.88	16.14	1.32	22.27	4.75	15.41
	-.-	1.59	3.69	-.-	-.-	-.-	-.-	-.-
	3.56	4.39	3.44	2.72	0.91	2.51	1.18	2.23
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	1.33	2.34	1.79	1.49	0.37	0.93	0.60	1.38
	0.78	0.76	0.10	0.32	0.39	0.39	0.39	0.34
	100.02	100.02	100.00	100.01	100.00	100.01	100.01	100.01
	11.63	13.24	63.06	47.79	2.25	40.76	8.26	52.78
	52.02	53.92	35.45	20.37	6.58	43.05	6.53	19.02

PLE	167	168	169	170	171	172	173	174
	16.81	16.03	15.71	15.14	4.55	2.99	-.-	-.-
	1.66	-.-	1.62	1.14	-.-	-.-	-.-	-.-
	12.00	7.80	13.24	9.26	4.02	18.00	8.95	15.57
	28.43	28.34	29.01	27.98	30.96	30.45	25.97	24.02
	19.37	26.06	19.93	24.92	21.78	24.09	23.41	27.73
	-.-	-.-	-.-	-.-	-.-	-.-	4.96	5.78
	-.-	0.74	-.-	-.-	10.80	1.77	21.85	14.35
	17.54	16.73	16.79	17.03	19.97	18.40	-.-	-.-
	-.-	-.-	-.-	-.-	-.-	-.-	10.26	6.97
	2.39	2.48	1.86	2.64	4.21	2.18	2.79	3.62
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	1.49	1.53	1.50	1.55	2.90	1.53	1.31	1.72
	0.32	0.32	0.35	0.34	0.83	0.59	0.50	0.25
	100.01	100.01	100.01	100.01	100.02	100.01	100.01	100.01
	40.53	47.90	40.73	47.10	41.30	44.17	40.61	45.17
	21.41	21.47	20.15	21.22	37.87	23.88	36.21	26.65

lk-feld qtz syenite(23b)
lbitite dike (23a)
asalt check
reywacke (9a)
lbitite dike (23a)
assive andesite (4a)
lbitite dike (23a)
arnet mica siltstone (9d)

167 greywacke (9a)
168 greywacke (9a)
169 garnet mica siltstone (9d)
170 greywacke (9a)
171 int tuff (5a)
172 siltstone (9b)
173 siltstone (9b)
174 siltstone (9b)

PLE	175A	175B	176	177	178	179	180	181
Z	21.21	-.-	7.17	22.80	2.13	9.36	8.97	89.53
)	2.29	0.77	-.-	2.10	-.-	-.-	-.-	-.-
R	9.66	17.41	2.73	14.69	5.25	19.92	11.69	1.52
3	44.87	36.42	29.93	43.09	25.18	29.58	16.38	6.43
N	10.84	24.09	22.60	10.28	26.02	20.48	23.69	0.46
E	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
[	-.-	-.-	6.17	-.-	8.81	0.29	6.55	0.74
(	8.36	11.42	24.28	5.16	27.38	16.13	26.26	1.00
;	-.-	4.44	-.-	-.-	-.-	-.-	-.-	-.-
T	1.50	2.82	4.20	0.74	2.91	2.12	3.40	0.13
M	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
;	1.03	1.76	2.58	0.82	2.08	1.55	2.64	0.15
P	0.24	0.88	0.34	0.32	0.24	0.59	0.43	0.03
M	100.00	100.02	100.01	100.00	100.01	100.01	100.01	99.99
n	19.46	39.81	43.02	19.27	50.83	40.91	59.13	6.74
I	10.89	20.44	37.23	6.72	41.18	20.09	38.85	2.02

PLE	182	183	184	185	186	187	188	189
Z	12.27	11.85	25.62	9.94	6.15	89.37	5.48	2.06
)	0.44	-.-	2.87	-.-	-.-	-.-	-.-	-.-
R	16.67	2.08	14.52	4.18	6.05	1.46	3.88	10.03
3	34.01	22.63	41.06	19.50	23.00	3.04	27.65	24.95
N	20.91	24.58	9.30	26.14	24.82	1.64	24.77	25.51
E	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	-.-	11.49	-.-	12.19	9.21	1.73	5.24	9.23
	12.33	20.49	4.09	21.03	23.30	1.45	26.16	20.72
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	1.66	4.12	1.40	4.14	4.35	0.89	3.80	4.35
	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
	1.31	2.44	0.81	2.51	2.75	0.37	2.69	2.75
	0.39	0.32	0.31	0.36	0.39	0.05	0.34	0.42
	100.01	100.01	100.00	100.01	100.01	99.99	100.01	100.01
	38.07	52.06	18.47	57.27	51.90	35.00	47.25	50.55
	15.31	38.54	6.31	39.88	39.60	4.44	37.89	37.05

siltstone (9b)
siltstone (9b)
qtz diorite
qtz plag porph dike (22a)
mafic tuff (4f)
qtz diorite (22b)
greywacke (9a)
mineralized qtz vein

182 qtz diorite (22b)
183 greywacke (9a)
184 qtz plag porph dike (22a)
185 greywacke (9a)
186 greywacke (9a)
187 mineralized qtz vein
188 greywacke (9a)
189 amyg basalt (4d)

LE 190	191	192	193	194	195	196	197
8.21	16.29	22.76	24.11	2.34	9.85	23.20	5.68
-.-	1.19	1.96	2.60	-.-	1.87	2.23	-.-
3.32	9.04	13.80	12.13	3.37	15.94	14.46	12.76
27.96	42.99	43.07	47.40	26.96	35.31	43.33	19.59
22.92	15.93	11.02	7.01	26.78	18.01	9.99	23.63
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
16.11	-.-	-.-	-.-	8.97	-.-	-.-	5.67
14.29	10.97	4.45	3.90	25.18	14.96	4.52	25.16
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
3.83	2.11	1.78	1.65	3.93	2.02	1.15	4.37
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
2.84	1.17	0.86	0.90	2.23	1.60	0.80	2.75
0.54	0.32	0.32	0.32	0.25	0.46	0.32	0.40
100.01	100.00	100.00	100.00	100.01	100.01	100.00	100.01
45.05	27.04	20.37	12.88	49.83	33.77	18.74	54.68
37.07	14.25	7.09	6.44	40.31	18.58	6.47	37.96

LE 198	199	200	201	202	203	204	205
12.45	26.00	32.27	13.78	24.73	23.17	23.30	3.86
1.44	3.43	2.40	-.-	-.-	2.60	2.34	-.-
14.066	17.68	13.97	12.59	8.16	14.36	12.36	3.20
35.98	35.37	32.76	28.36	26.06	23.51	31.22	26.67
19.39	9.74	11.63	23.39	24.25	17.19	14.46	25.13
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
-.-	-.-	-.-	1.16	0.86	-.-	-.-	12.84
12.82	4.96	4.52	16.84	10.98	15.41	12.76	21.40
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
2.03	1.57	1.36	2.06	3.28	2.13	1.91	3.77
-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-
1.41	0.91	0.81	1.53	1.38	1.32	1.33	2.53
0.41	0.34	0.29	0.30	0.29	0.32	0.32	0.62
100.01	100.00	100.00	100.00	100.00	100.00	100.00	100.01
35.02	21.59	26.21	45.20	48.20	42.23	31.66	48.51
16.26	7.45	6.69	21.58	16.51	18.86	16.01	40.54

greywacke (9a)
siltstone (9b)
qtz plag porph dike (22a)
qtz plag porph dike (22a)
greywacke (9a)
qtz diorite (22b)
qtz plag porph dike (22a)
greywacke (9a)

198 qtz diorite (22b)
199 qtz plag porph dike (22a)
200 qtz plag porph dike (22a)
201 greywacke (9a)
202 greywacke (9a)
203 garnet mica siltstone (9d)
204 siltstone (9b)
205 greywacke (9a)

PLE 206	207	208	209
17.90	1.48	34.34	33.47
-.-	-.-	5.43	1.09
8.63	2.91	16.81	9.50
26.19	28.73	32.66	27.38
26.40	26.77	6.80	17.43
-.-	-.-	-.-	-.-
1.82	12.51	-.-	-.-
14.28	20.49	1.74	7.15
-.-	-.-	-.-	-.-
2.97	4.21	0.83	2.89
-.-	-.-	0.85	-.-
1.45	2.53	0.41	0.88
0.37	0.37	0.12	0.22
100.01	100.01	100.00	100.00
50.20	48.23	17.22	38.90
20.52	39.74	3.83	10.92

greywacke (9a)
greywacke (9a)
granodiorite dike (17)
dacitic tuff (6a)

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